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(54) **VARIABLE TEMPERATURE SEAT CLIMATE CONTROL SYSTEM**

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Related U.S. Patent Documents

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Issued: **Jun. 11, 1996**
Appl. No.: **08/156,052**
Filed: **Nov. 22, 1993**

U.S. Applications:
(

(62) Division of application No. 09/621,258, filed on Jul. 20, 2000, now abandoned.

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(52) **U.S. Cl.** **62/3.5**; 62/3.61; 62/261
(58) **Field of Search** 62/3.5, 3.6, 3.61, 62/261, 3.3; 236/49.3

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(57) **ABSTRACT**

A temperature climate control system comprises a variable temperature seat, at least one heat pump, at least one heat pump temperature sensor, and a controller. Each heat pump comprises a number of Peltier thermoelectric modules for temperature conditioning the air in a main heat exchanger and a main exchanger fan for passing the conditioned air from the main exchanger to the variable temperature seat. The Peltier modules and each main fan may be manually adjusted via a temperature switch and a fan switch, respectively. Additionally, the temperature climate control system may comprise a number of additional temperature sensors to monitor the temperature of the ambient air surrounding the occupant as well as the temperature of the conditioned air directed to the occupant. The controller is configured to automatically regulate the operation of the Peltier modules and/or each main fan according to a temperature climate control algorithm designed both to maximize occupant comfort during normal operation, and minimize possible equipment damage, occupant discomfort, or occupant injury in the event of a heat pump malfunction.

25 Claims, 8 Drawing Sheets

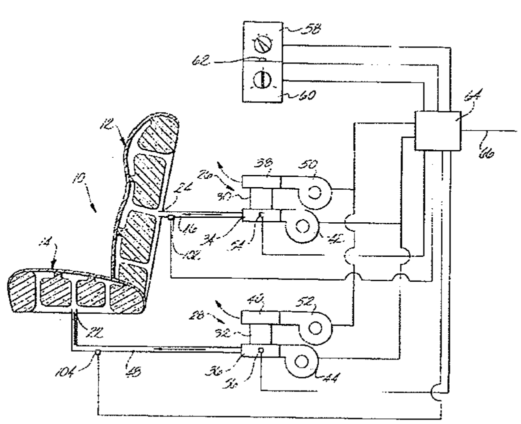
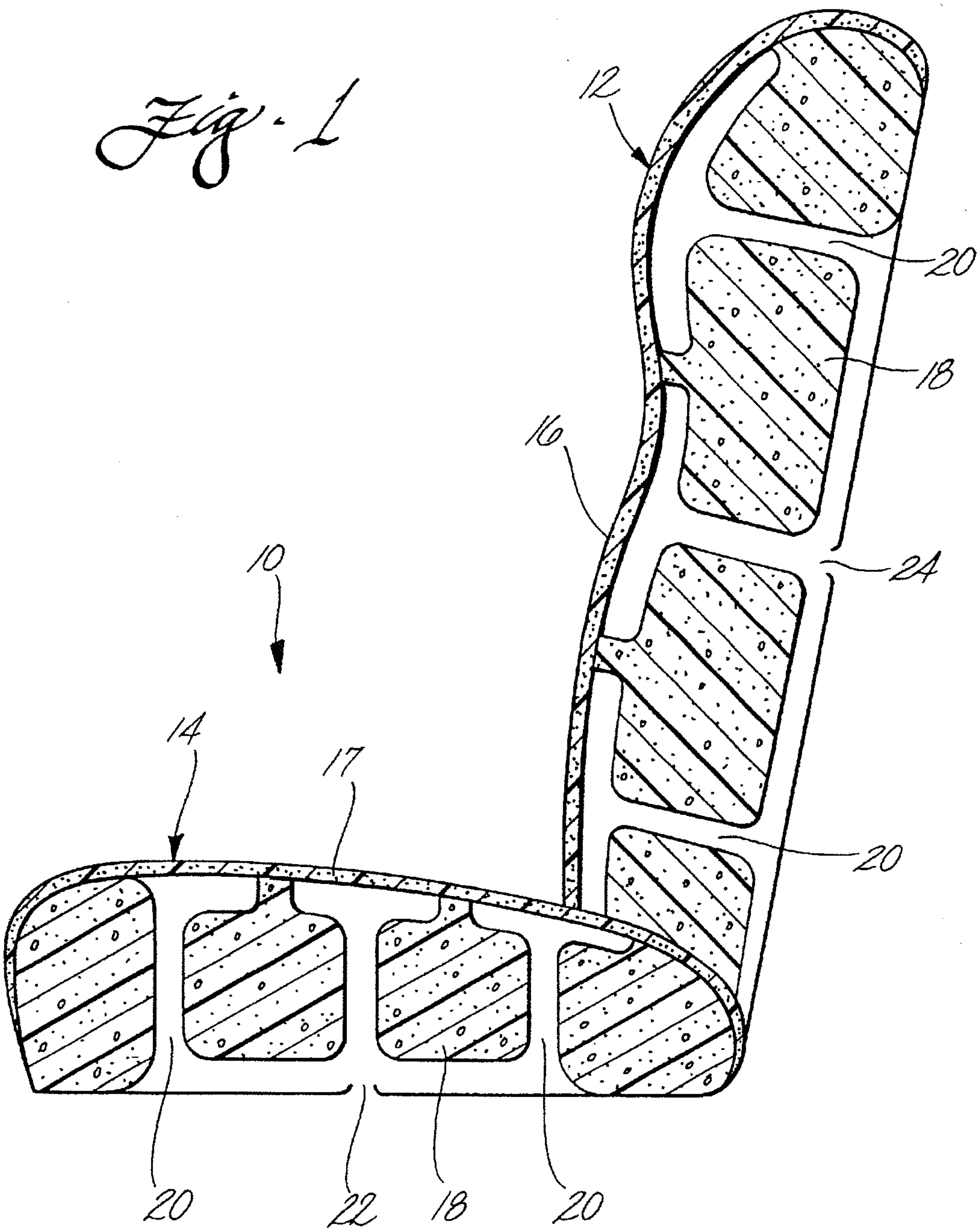
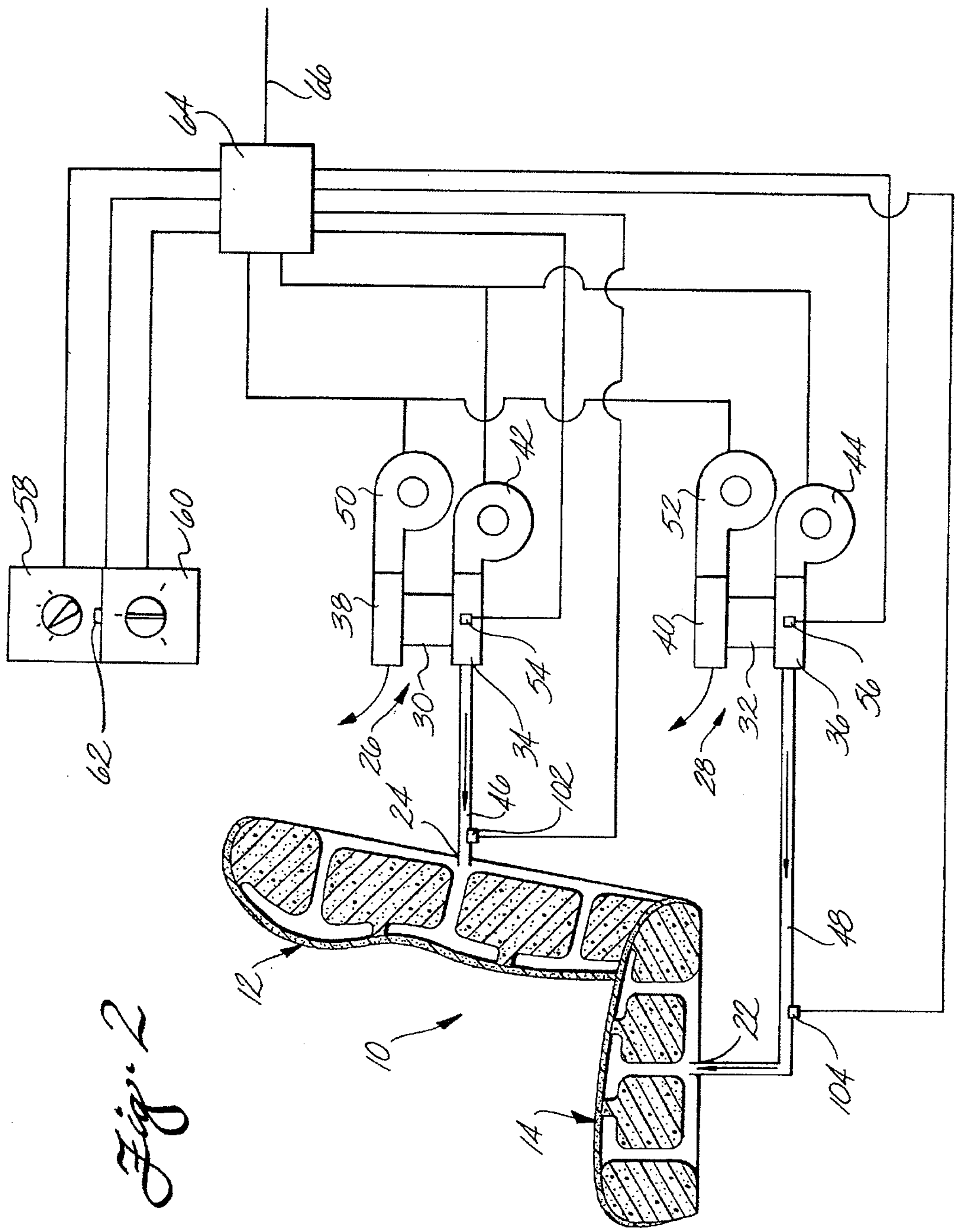


Fig. 1

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64
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62
50
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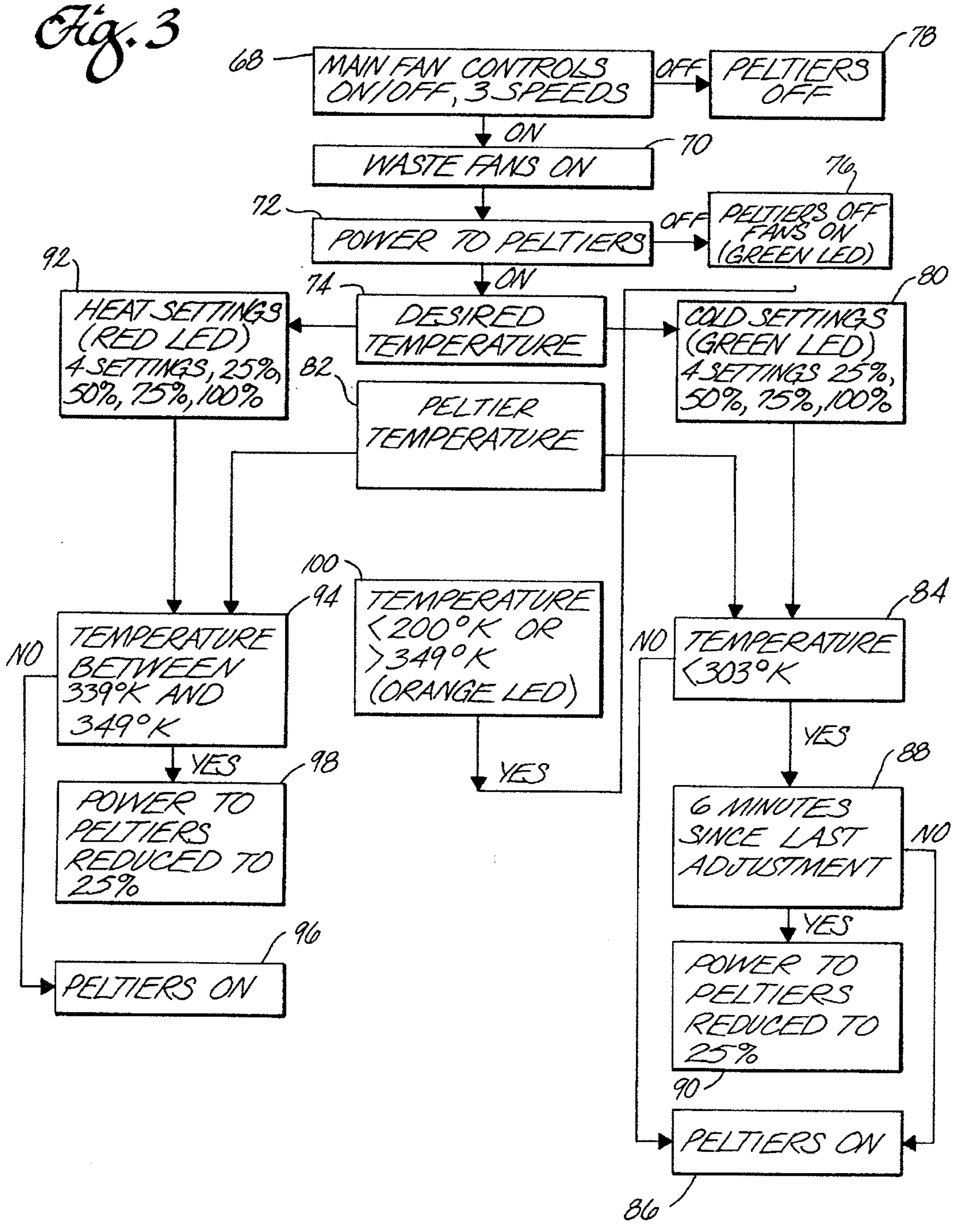
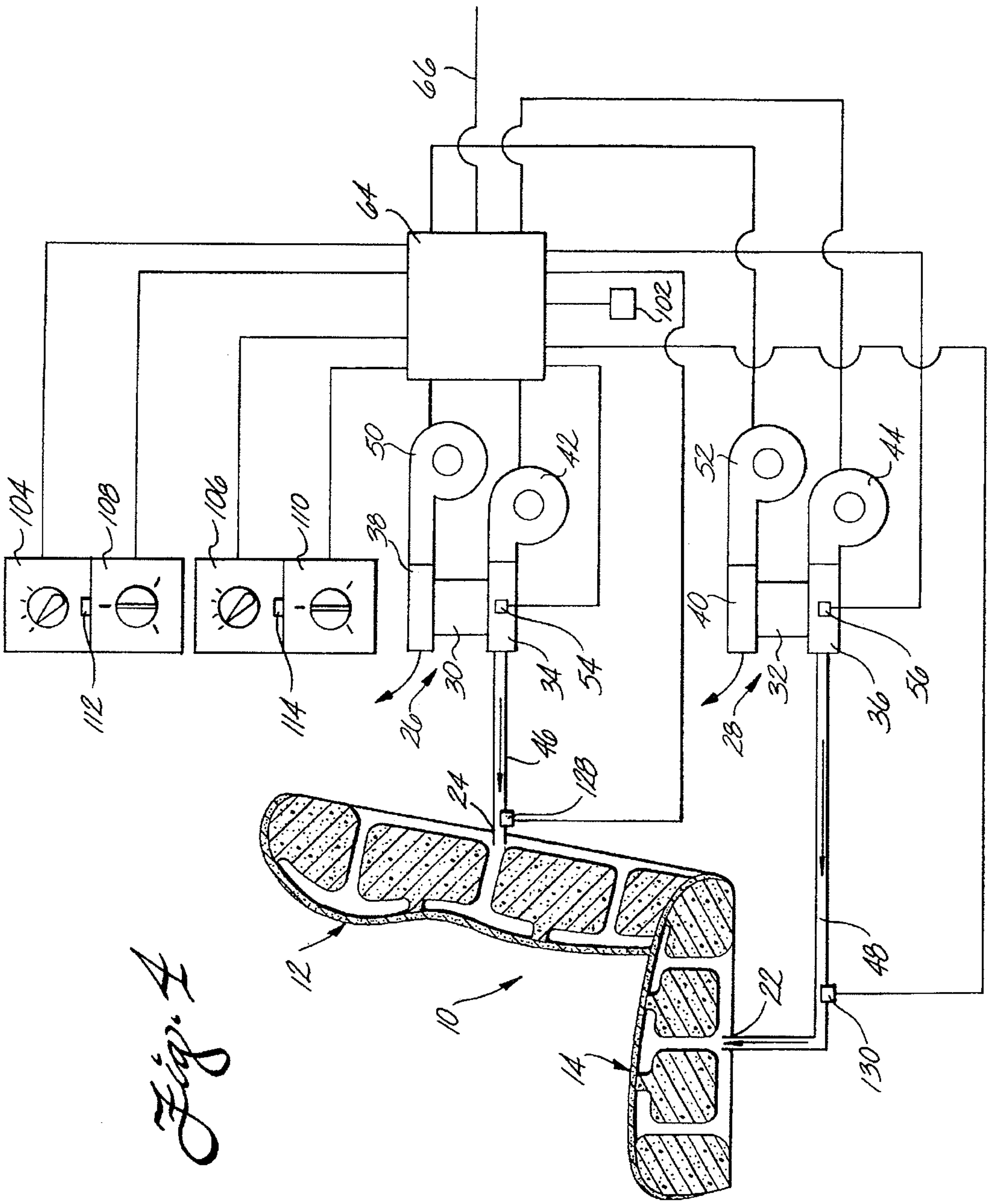
104
14
Fig. 2

Fig. 3



68
MAIN FAN CONTROLS ON/OFF, 3 SPEEDS
OFF
PELTIERS OFF
78
ON
WASTE FANS ON
70
72
POWER TO PELTIERS
OFF
PELTIERS OFF FANS ON (GREEN LED)
76
ON
74
DESIRED TEMPERATURE
92
HEAT SETTINGS (RED LED) 4 SETTINGS, 25%, 50%, 75%, 100%
COLD SETTINGS (GREEN LED) 4 SETTINGS 25%, 50%, 75%, 100%
80
82
PELTIER TEMPERATURE
100
94
TEMPERATURE BETWEEN 339°K AND 349°K
NO
TEMPERATURE <200°K OR >349°K (ORANGE LED)
YES
NO
TEMPERATURE <303°K
84
YES
98
POWER TO PELTIERS REDUCED TO 25%
YES
88
6 MINUTES SINCE LAST ADJUSTMENT
NO
YES
96
PELTIERS ON
POWER TO PELTIERS REDUCED TO 25%
90
PELTIERS ON
86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42
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44
38
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112
114
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128
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12
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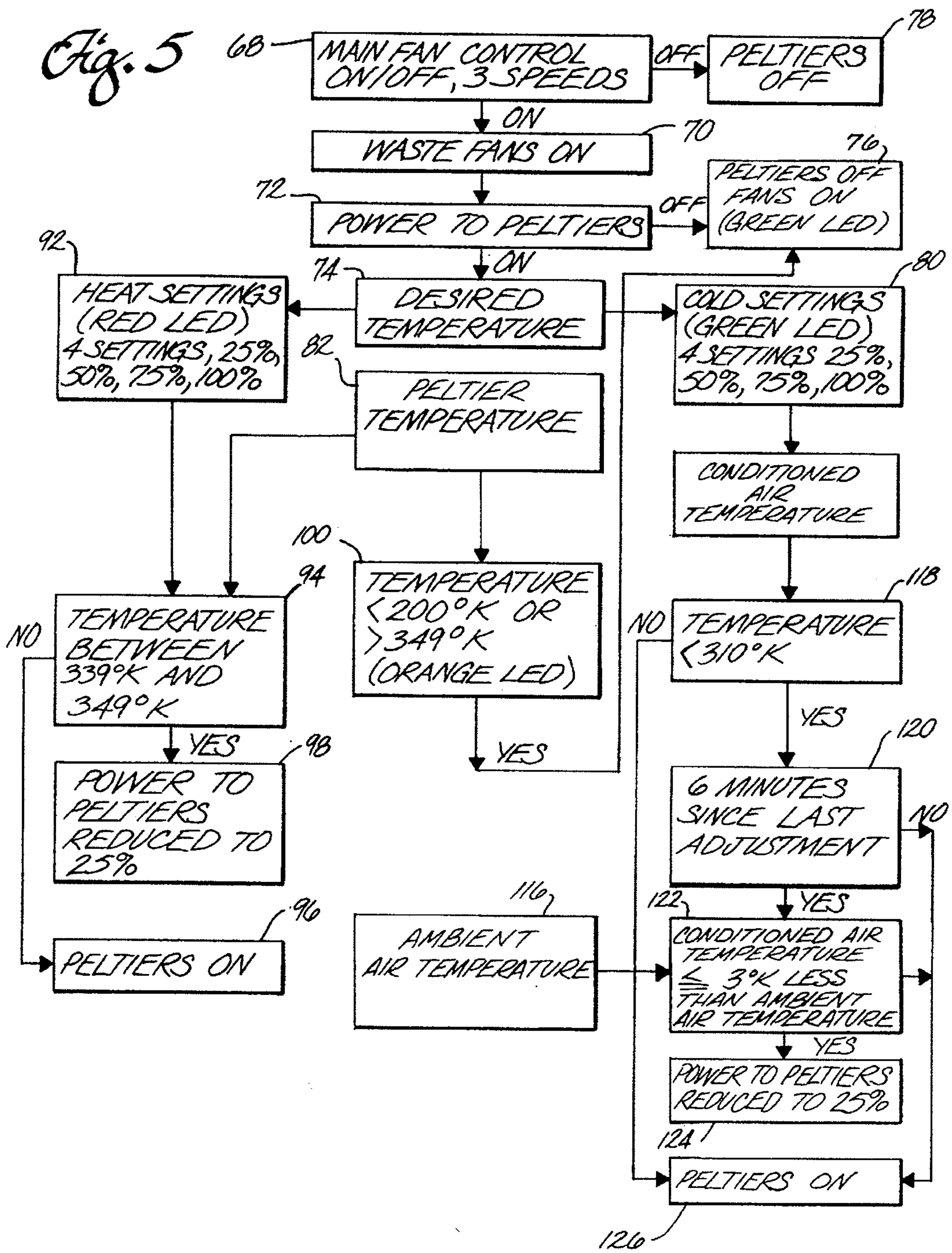
48
14
130

Fig. 4

Fig. 5


MAIN FAN CONTROL ON/OFF, 3 SPEEDS
68
OFF
PELTIERS OFF
78
ON
WASTE FANS ON
70
72
POWER TO PELTIERS
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PELTIERS OFF FANS ON (GREEN LED)
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92
HEAT SETTINGS (RED LED) 4 SETTINGS, 25%, 50%, 75%, 100%
80
COLD SETTINGS (GREEN LED) 4 SETTINGS 25%, 50%, 75%, 100%
82
PELTIER TEMPERATURE
CONDITIONED AIR TEMPERATURE
100
TEMPERATURE <200°K OR >349°K (ORANGE LED)
94
TEMPERATURE BETWEEN 339°K AND 349°K
NO
YES
98
POWER TO PELTIERS REDUCED TO 25%
YES
NO
118
TEMPERATURE <310°K
YES
120
6 MINUTES SINCE LAST ADJUSTMENT
NO
YES
116
AMBIENT AIR TEMPERATURE
122
CONDITIONED AIR TEMPERATURE ≤ 3°K LESS THAN AMBIENT AIR TEMPERATURE
YES
POWER TO PELTIERS REDUCED TO 25%
124
96
PELTIERS ON
PELTIERS ON
126

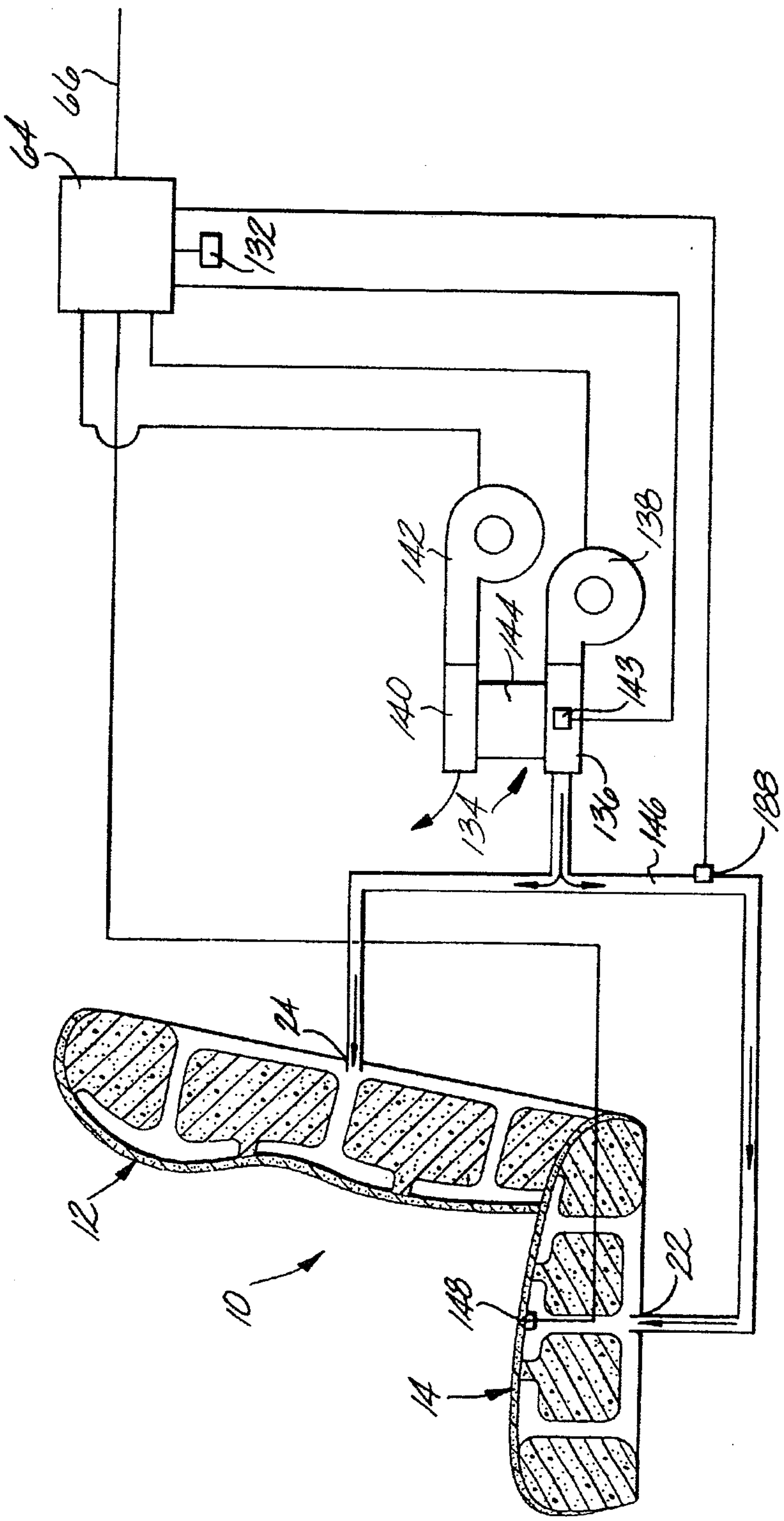
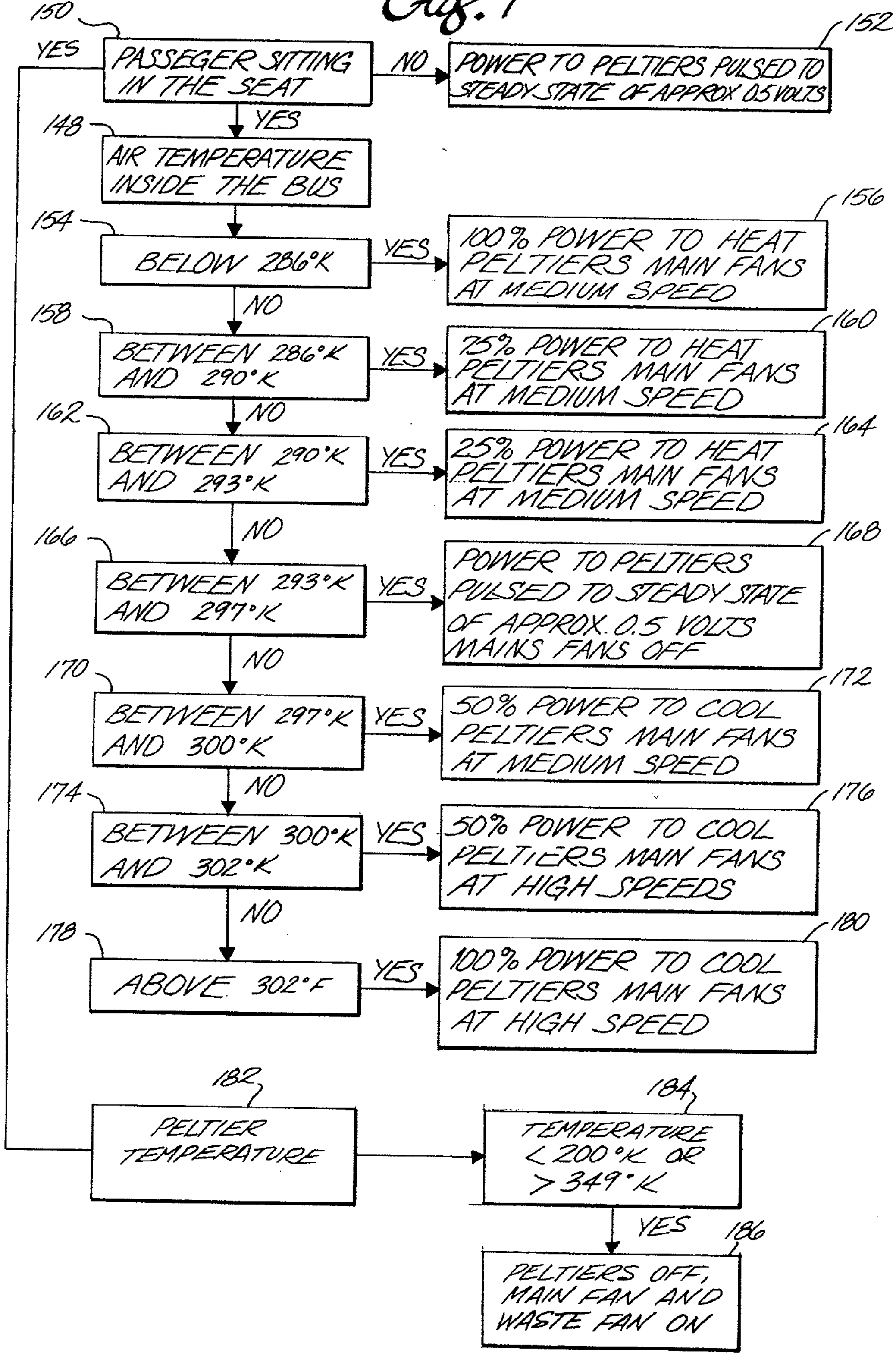


Fig. 6

Fig. 7


150
YES
PASSEGER SITTING IN THE SEAT
NO
152
POWER TO PELTIERS PULSED TO STEADY STATE OF APPROX 0.5 VOLTS
148
YES
AIR TEMPERATURE INSIDE THE BUS
154
BELOW 286°K
YES
156
100% POWER TO HEAT PELTIERS MAIN FANS AT MEDIUM SPEED
NO
158
BETWEEN 286°K AND 290°K
YES
160
75% POWER TO HEAT PELTIERS MAIN FANS AT MEDIUM SPEED
162
NO
BETWEEN 290°K AND 293°K
YES
164
25% POWER TO HEAT PELTIERS MAIN FANS AT MEDIUM SPEED
NO
166
BETWEEN 293°K AND 297°K
YES
168
POWER TO PELTIERS PULSED TO STEADY STATE OF APPROX. 0.5 VOLTS MAINS FANS OFF
NO
170
BETWEEN 297°K AND 300°K
YES
172
50% POWER TO COOL PELTIERS MAIN FANS AT MEDIUM SPEED
NO
174
BETWEEN 300°K AND 302°K
YES
176
50% POWER TO COOL PELTIERS MAIN FANS AT HIGH SPEEDS
NO
178
ABOVE 302°F
YES
180
100% POWER TO COOL PELTIERS MAIN FANS AT HIGH SPEED
182
PELTIER TEMPERATURE
184
TEMPERATURE < 200°K OR > 349°K
YES
186
PELTIERS OFF, MAIN FAN AND WASTE FAN ON

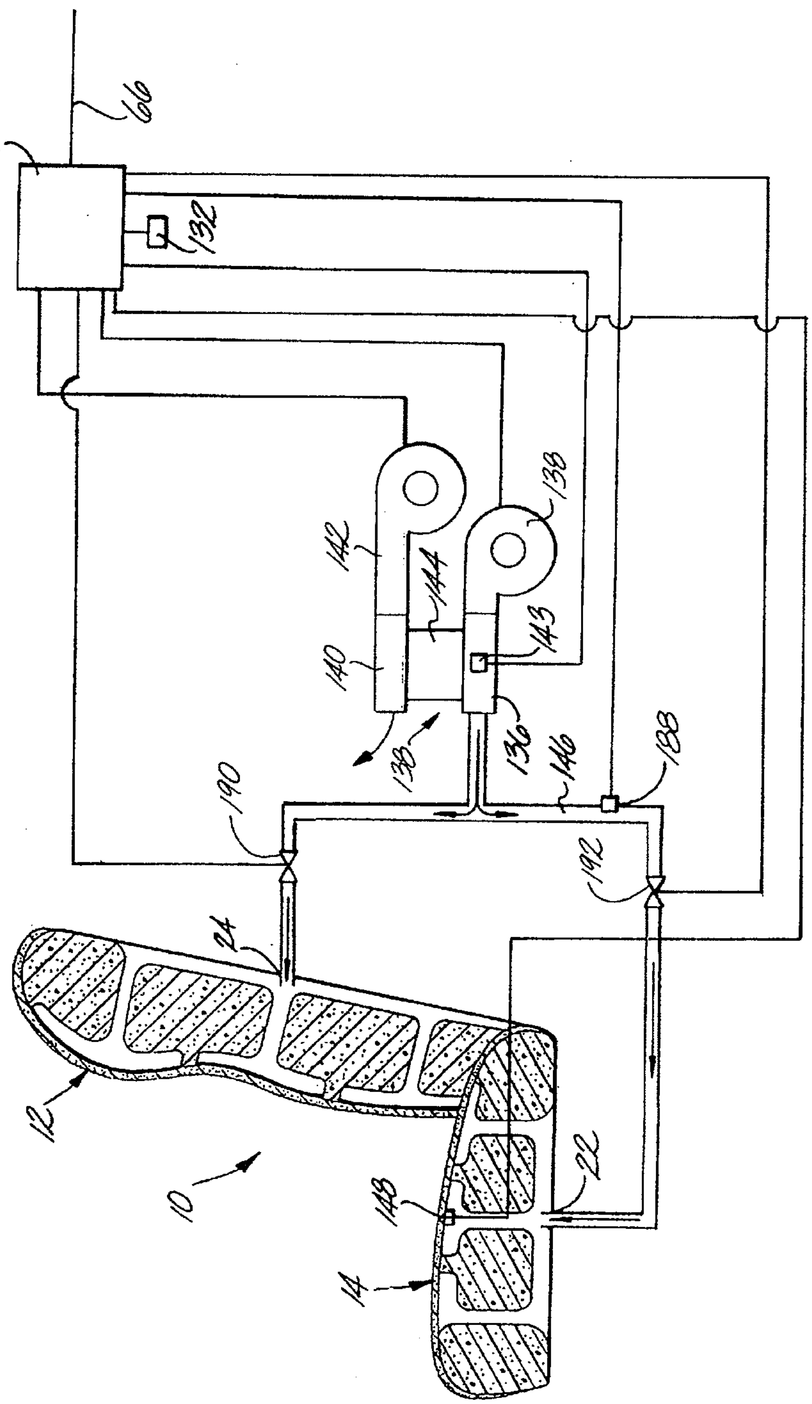

64
66
132
138
142
144
143
140
130
136
146
188
190
192
24
12
10
22
148
14

Fig. 8

VARIABLE TEMPERATURE SEAT CLIMATE CONTROL SYSTEM

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

Application Ser. No. 09/621,258 was filed Jul. 20, 2000 as a continuation of the present case, and is now abandoned.

FIELD OF THE INVENTION

The present invention relates generally to a variable temperature seat and, more specifically, to a method and apparatus for controlling the flow and temperature of a heating or cooling medium through the seat to an occupant positioned in such seat.

BACKGROUND OF THE INVENTION

Cooling or heating occupants of buildings, homes, automobiles and the like is generally carried out by convection through modifying the temperature of air surrounding the occupants environment. The effectiveness of convection heating or cooling is largely dependent on the ability of the temperature conditioned air to contact and surround all portions of the occupants's body. Heating and cooling occupants through convention is generally thought to be efficient in such applications as homes, offices, and other like structures where the occupants are not stationary or fixed in one position but, rather are moving around allowing maximum contact with the temperature treated air.

In other applications such as automobiles, planes, buses and the like, the occupants are typically fixed in one position with a large portion of their body's surface against the surface of a seat, isolated from effects of the temperature conditioned air. In such applications the use of distributing temperature conditioned air into the cabin of the vehicle to heat or cool the occupant is less effective due to the somewhat limited surface area of contact with the occupant's body. In addition, oftentimes the surface of the seat is at a temperature close to the ambient temperature upon initial contact by the occupant, increasing the need to provide rapid temperature compensation to the occupant in an effective manner.

To address the problem of providing effective occupant heating or cooling in such applications, seats have been constructed to accommodate the internal flow of a heating or cooling medium and to distribute the same through the seating surface to the surface of the occupant in contact with the seat. A preferred heating and cooling medium is air. A seat constructed in this manner increases the efficiency of heating or cooling a passenger by convection by distributing temperature conditioned air directly to the surface the occupant generally isolated from contact with temperature conditioned air that is distributed throughout the cabin of the vehicle.

U.S. Pat. No. 4,923,248 issued to Feher discloses a seat pad and backrest comprising an internal plenum for distributing temperature conditioned air from a Peltier thermoelectric module through the surface of the seat pad and to an adjacent surface of an occupant. The temperature conditioned air is provided by using a fan to blow ambient air over the fins of a Peltier module. The heating or cooling of the occupant is achieved by changing the polarity of the electricity that powers the Peltier module.

U.S. Pat. No. 5,002,336 issued to Feher discloses a joined seat and backrest construction comprising an internal plenum for receiving and distributing temperature conditioned air through the seat and to an adjacent surface of an occupant. Like U.S. Pat. No. 4,923,248, the temperature conditioned air is provided by a Peltier thermoelectric module and distributed through the internal plenum by an electric fan.

U.S. Pat. No. 5,117,638 issued to Feher discloses a selectively cooled or heated seat construction and apparatus for providing temperature conditioned air. The seat construction comprising, an internal plenum, a plastic mash layer, a metal mesh layer, and perforated outer layer. The apparatus for providing the temperature conditioned air is heat exchanger comprising a Peltier thermoelectric module and a fan. Heating or cooling the occupant is achieved by switching the polarity of the electricity powering the Peltier module.

The seat constructions known in the art, although addressing the need to provide a more efficient method of heating or cooling the occupant, has not addressed the need to provide temperature conditioned air to an occupant in a manner that both maximizes occupant comfort and maximizes power efficiency.

The ever increasing awareness of our environment and the need to conserve resources has driven the need to replace hydrocarbon powered vehicles, such as the automobile, with vehicles that are powered by an environmentally friendly power sources such as electricity. The replacement of current hydrocarbon automobiles with electric powered vehicles will only become a reality if the electric powered vehicle can be operated and maintained in a manner equaling or bettering that of the hydrocarbon powered automobile it replaces. Accordingly, the need for electric vehicles to perform in an electrically efficient manner, is important to the success of the electric vehicle.

In order to maximize the electrical efficiency of the electric powered vehicle it is necessary that the electrically powered ancillary components of the electric vehicle function at maximum electrical efficiency. The seats known in the art that provide temperature conditioned air to an occupant do not operate in an electrically efficient manner. The temperature of the air being conditioned by the Peltier thermoelectric devices in such seats is adjusted by dissipating the excess power through a resister, i.e., by using a potentiometer. The practice of dissipating excess power instead of providing only that amount of power necessary to operate the Peltier thermoelectric devices makes such seats unsuited for such power sensitive applications as the electric vehicle as well as other applications where electrical efficiency is a concern.

The seats known in the art constructed to provided temperature conditioned air to an occupant are adjustable in that the occupant may either choose to produce heated air or cooled air. However, the seats known in the art are unable to automatically regulate the temperature or flow rate of the cool or heated air distributed to the occupant in the event that the thermoelectric device malfunctions or in the event that the user falls asleep. An electrical malfunctioning of the thermoelectric device could result in the abnormal heating of the device, causing damage to the thermoelectric device itself. An electrical malfunction could result in the distribution of hot air to the occupant, causing discomfort or even injury. Additionally, an initial temperature setting of maximum heat or maximum cold that is left untouched in the event the occupant falls asleep may cause damage to the thermoelectric device itself or may cause discomfort or even injury to the occupant.

The seats known in the art, while able to vary the distribution of air to the seat bottom or seat back via occupant adjustment, do not allow the occupant to vary the temperature of the air passing through the seat back or seat bottom, independently. The option of being able to selectively heat one portion of the seat and cool the other may be desirable where the occupant requires such selective treatment due to a particular medical condition or injury. For example, one a cold day it would be desirable to distribute heated air to the seat back for occupant comfort and cooled air to the seat bottom to assist in healing a leg injury that has recently occurred.

It is, therefore, desirable that a variable temperature seat comprise a control system and method for regulating the temperature and flow rate of temperature conditioned air to an occupant sitting in the seat. It is desirable that the control system operate the seat in an electrically efficient manner, making it ideal for use in power sensitive applications such as the electric powered vehicle. It is desirable that the control system operate the seat in a manner eliminating the possibility of equipment damage, occupant discomfort or injury. It is also desirable that the control system permit the independent distribution of heated or cooled air to the seat back or seat bottom.

SUMMARY OF THE INVENTION

There is, therefore, provided in practice of this invention a temperature climate control system for use with a variable temperature seat. The temperature climate control system comprises a variable temperature seat suitable for distributing temperature conditioned air to a seated occupant, at least one heat pump for temperature conditioning ambient air and passing the air to the seat, a temperature sensor located at each heat pump, and a controller configured to monitor the temperature of the heat pumps and regulate their operation according to a temperature climate control algorithm.

Each heat pump comprises a number of Peltier thermoelectric modules for selectively heating or cooling ambient air in a main heat exchanger. The heated or cooled air is passed to the seat by a main exchanger fan. Each heat pump also comprises a waste heat exchanger for removing unwanted heat or cooling from the Peltier modules. The unwanted heat or cooling is passed to the outside environment by a waste exchanger fan.

Each main fan may be manually adjusted to operate at a variety of predetermined speeds via a fan switch. Each Peltier module can be manually adjusted to operate in various heating or cooling modes via a temperature switch. The electrical power to each Peltier is pulsed at a duty cycle corresponding to a particular heating or cooling mode of operation to optimize electrical efficiency. Each heat pump may be operated independently via separate fan and temperature switches, or may be operated simultaneously by a common fan and temperature switch. Alternatively, each heat pump may be operated automatically by the controller when the variable temperature seat is occupied by the activation of an occupant presence switch.

After an initial fan speed and Peltier temperature setting has been selected, the controller monitors the temperature information relayed from each heat pump. In addition, the controller may also be configured to monitor the ambient temperature of the air surrounding the variable temperature seat occupant as well as the temperature of the conditioned air directed to the variable temperature seat occupant, via the use of additional temperature sensors. The controller regulates the operation of each main exchanger fan, each waste exchanger fan, and each Peltier module according to a temperature climate control algorithm. The control algorithm is designed to maximize occupant comfort and minimize the possibility of equipment damage, occupant discomfort or even occupant injury in the event of a system malfunction.

The control algorithm is designed to interrupt or limit the power to the Peltier modules and/or each main exchanger fan in the event that the heat pump temperature exceeds a predetermined maximum temperature or a predetermined minimum temperature, indicating a possible heat pump malfunction. Additionally, the control algorithm is designed to interrupt power to the Peltier modules in the event that the temperature of the conditioned air directed to the variable temperature seat occupant exceeds a predetermined maximum or minimum temperature.

The control algorithm is also designed to limit the power to the Peltier modules during the cooling mode of operation when the temperature of the cooling air directed to the occupant exceeds a predetermined minimum cooling temperature and the temperature has not been adjusted for a predetermined period of time, thus minimizing possible occupant discomfort associated with overcooling the occupant's back. In addition, the control algorithm is designed to limit the power to the Peltier modules during the cooling mode of operation when the temperature difference between the ambient air surrounding the variable temperature seat occupant and the conditioned air directed to the occupant is greater than a predetermined amount.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features and advantages of the present invention will become appreciated as the same becomes better understood with reference to the specification, claims and drawings wherein:

FIG. **1** is a cross-sectional semi-schematic view of an embodiment of a variable temperature seat;

FIG. **2** is a schematic view of a first embodiment of the temperature climate control system according to the present invention;

FIG. **3** is a flow chart illustrating a temperature climate control algorithm for the embodiment of the invention shown in FIG. **2**;

FIG. **4** is a schematic view of a second embodiment of the temperature climate control system according to the present invention;

FIG. **5** is a flow chart illustrating a temperature climate control algorithm for the embodiment of the invention shown in FIG. **4**;

FIG. **6** is a schematic view of a third embodiment of the temperature control climate control system according to the present invention;

FIG. **7** is a flow chart illustrating a temperature climate control algorithm for the embodiment of the invention shown in FIG. **6**; and

FIG. **8** is a schematic view of an alternative embodiment of the temperature climate control system according to the present invention.

DETAILED DESCRIPTION

A temperature climate control system (TCCS) provided in the practice of this invention may be used to control the temperature of air being distributed through a variable temperature seat (VTS) and directed to a seated occupant.

The TCCS may be used in various VTS applications where it is required that an occupant stay seated for a period of time, such as automobiles, trains, planes, buses, dentists chairs, hair styling chairs and the like, or where an occupant simply desires an added degree of comfort while he/she is sitting at work or in the home, such as office chairs, home recliners and the like. The TCCS configured according to the practice of this invention to operate in a manner providing an occupant seated in a VTS a maximum degree of comfort by allowing the occupant to manually adjust both the flow rate and the temperature of the air being passed through the seat surface and directed to the occupant.

The TCCS is configured to automatically override the manual flow rate and temperature settings when it senses that the temperature of the air being directed to the occupant is above a predetermined maximum temperature set point or is below a predetermined minimum temperature set point. Thus, maximizing both occupant comfort and occupant safety in the event that the occupant either falls asleep or in the event that the device generating the temperature conditioned air malfunctions. The TCCS also comprises timers and is configured to automatically override the manual flow rate and temperature settings during normal operation to prevent back discomfort. Additionally, the device generating the temperature conditioned air is operated in a manner maximizing electrical efficiency, making it well suited for use in applications that are sensitive to electrical consumption, such as electric powered vehicles.

FIG. **1** shows an embodiment of a VTS **10** comprising a seat back **12** and a seat bottom **14** for accommodating the support of a human occupant in the sitting position. FIG. **1** shows a simplified cross-sectional view of a VTS for purposes of illustration and clarity. Accordingly, it is to be understood that the VTS may be constructed in embodiments other than that specifically represented. The VTS may be constructed having a outside surface covering **16** made from a suitable material that allows the flow of air through its surface, such as perforated vinyl, cloth, leather or the like. A padding layer **17** such as reticulated foam may lie beneath the outside surface **16** to increase occupant comfort.

The VTS may be constructed having a metal frame (not shown) that generally defines the seat configuration and having seat bottom and seat back cushions **18** made from foam and the like. A number of air channels **20** are positioned within each seat cushion and extend from the padding layer **17** through the seat cushions and to either a seat bottom air inlet **22** or a seat back air inlet **24**. Although a particular embodiment of a VTS has specifically described, it has to be understood that the TCCS according to the present invention is meant to operate with any type of VTS having the same general features.

FIG. **2** shows a first embodiment of the TCCS according to the present invention comprising a VTS **10**. The air that is passed through the seat and to the occupant is temperature conditioned by a heat pump. This first embodiment comprises a seat back heat pump **26** for temperature conditioning the air passed through the seat back **12** of the VTS, and a seat bottom heat pump **28** for temperature conditioning the air passed through the seat bottom **14** of the VTS. The seat back heat pump and seat bottom heat pump each comprise at least one thermoelectric device **30** and **32**, respectively, for temperature conditioning, i.e., selectively heating or cooling, the air. A preferred thermoelectric device is a Peltier thermoelectric module. Each heat pump may comprise more than one Peltier thermoelectric module. A preferred heat pump comprises approximately three Peltier thermoelectric modules.

Each heat pump comprises a main heat exchanger **34** and **36**, enclosing air temperature conditioning fins (not shown) depending from one surface of the Peltier modules, and a waste heat exchanger **39** and **40**, enclosing thermal exchanger fins (not shown) extending from the Peltier module surface opposite the main heat exchanger. Attached to one end of each main heat exchanger is an outlet from a main exchanger fan **42** and **44** that serves to pass the temperature conditioned air in each main heat exchanger to the seat back or seat bottom, respectively. Each main exchanger fan may comprise an electrical fan having a suitable flow rate, such as an axial blower and the like. The outlet end of each main heat exchanger is connected to an air conduit **46** and **48** that is connected to the respective seat back air inlet **24** or seat bottom air inlet **22**. Accordingly, the temperature conditioned air produced by the Peltier thermoelectric modules in each main heat exchanger is passed through the respective air conduit, through the respective air inlet, into and through the respective seat portion of the VTS to the occupant by the main exchanger fan.

Attached to one end of each waste heat exchanger is an outlet from a waste exchanger fan **50** and **52** that serves to pass unwanted waste heat or cooling produced in each waste heat exchanger to the outside environment surrounding the VTS. Each waste exchanger fan may comprise an electrical fan having a suitable air flow rate, such as an axial blower and the like. The waste air exiting each waste heat exchanger fan is usually at an undesirable temperature, i.e., in the cooling mode it is hot air and in the heating mode it is cold air. Consequently, waste air exiting each waste exchanger may be specifically routed away from any occupant, possibly through the sides of the seat or the like.

Attached to the main exchanger side of the Peltier thermoelectric modules in each heat pump is a temperature sensor **54** and **56**. Each temperature sensor may comprise an electric thermocouple and the like.

The operation of the main exchanger fans **42** and **44** can be manually controlled by a fan switch **58**. In the first embodiment, it is preferred that the main exchanger fans are operated simultaneously by a single fan switch. The fan switch may comprise an electrical switch configured to provide an off position, and a variety of fan speed settings if desired. It is preferred that the fan switch be configured having an off position and three different fan speed settings, namely low, medium and high. The fan switch may be located within or near the VTS for easy occupant access.

The operation of the waste exchanger fans **50** and **52** can be manually controlled by a separate fan switch (not shown) if desired. However, it is preferred that the waste exchanger fans be activated automatically upon the operation of the main exchanger fans and operate at a single predetermined speed. Accordingly, upon the manual operation of the fan switch **58**, both the main exchanger fans are activated to a selected speed and the waste exchanger fans are automatically activated to operate at maximum speed. Configuring the TCCS to operate in this manner maximizes the thermal efficiency of the Peltier modules and reduces the possibility of system damage.

The operation of the Pelter thermoelectric modules can be controlled by a temperature switch **60**. In the first embodiment it is preferred that the Peltier thermoelectric modules in both heat pumps be operated simultaneously by a single temperature switch. The temperature switch may comprise an electrical switch configured to provide an off position, and a variety of temperature settings if desired. A preferred fan switch is configured having an off position, four heating

positions, and four cooling positions. Like the fan switch **58**, the temperature switch **60** may be located within or near the VTS for easy occupant access.

When the temperature switch is turned to one of the cooling positions a LED lamp **62** located near the temperature switch registers a green color, indicating that the Peltier modules are operating in the cooling mode. When the temperature switch is turned to one of the heating positions the LED lamp registers a red color, indicating the Peltier modules are operating in the heating mode.

The different heating or cooling modes for the Peltier modules is accomplished by both switching the polarity and limiting the amount of the electrical power routed to the Peltier modules. To optimize the electrical efficiency of the Peltier modules, instead of using a potentiometer to discharge the unwanted portion of the electrical power through a resister, the four different modes of heating and cooling operation are achieved by pulsing electrical power to the Peltier modules at predetermined duty cycles. Accordingly, the different levels of heating or cooling are accomplished by pulsing the electrical power to the Peltier modules at a predetermined duty cycle. In a preferred embodiment, the duty cycle is about 0.02 seconds (50 hz) and the four different levels are accomplished by applying either 25 percent, 50 percent, 75 percent, or 100 percent of the cycle time power. In this embodiment, a 25 percent duty cycle would be on for approximately 0.005 seconds and off for approximately 0.015 seconds for a total cycle length of 0.02 seconds, and then repeated. The 75 percent duty cycle is on for approximately 0.015 seconds and off for approximately 0.005 seconds.

The heating or cooling mode of the Peltier modules is achieved by switching the polarity of the electrical power. The Peltier modules are configured to operate in the heating mode on approximately ten volts DC and in the cooling mode on approximately six volts DC. A DC converter may be positioned outside the controls to supply the heating and cooling voltage. The total duty cycle of the Peltier modules is adjustable from 0.02 to 0.2 seconds. The power for the Peltier modules in each mode was chosen to optimize the efficiency and total thermal power supplied to an occupant of the VTS.

The electrical feeds to and/or outlets from the fan switch **58**, temperature switch **60**, main exchanger fans **42** and **44**, waste exchanger fans **50** and **52**, Peltier thermoelectric modules **30** and **32** LED lamp **62**, and temperature sensors **54** and **56** and routed to a controller **64**. Alternatively, the electrical feeds ad signals may first be routed to a printed circuit board in the seat (not shown) that sends a signal to the controller. The controller comprises a power inlet **66** of sufficient electrical capacity to operate all of the aforementioned devices. The controller is configured to receive occupant inputs from the fan switch and the temperature switch and temperature information from the temperature sensors. From this input the controller is configured to make adjustments to the operation of the heat pumps according to a predetermined algorithm designed to ensure occupant comfort and safety, and protect against system damage.

FIG. **3** is a flow chart illustrating a temperature climate control algorithm for the first embodiment of the TCCS shown in FIG. **2**. The occupant wishing to use the VTS operates the main exchanger fans by activating the fan switch **58** and selecting a desired fan speed (step **68**). Upon the activation of the main exchanger fans the waste exchanger fans are also activated to operate at a maximum speed (step **70**).

The occupant may activate the Peltier modules for temperature conditioning the air in the VTS by positioning the temperatures witch **60** to a desired heating or cooling mode (steps **72** and **74**). The Peltier modules can be manually deactivated by selecting the "off" position on the temperature control switch, in which case the power to the fans is maintained as indicated by the LED **62** registering a green color (step **76**). Additionally, the Peltier modules are automatically deactivated by the controller when the fan switch is manually placed in the "off" position (step **78**).

When the temperature switch is positioned to one of the four cooling modes the LED lamp **62** registers a green color (step **80**). The temperature detected by the temperature sensors **54** and **56** in both heat pumps **26** and **28** is passed to the controller (step **82**). If the temperature is below about 303° K. (step **84**) the power to the Peltier modules remains on (step **86**), unless more than six minutes has elapsed since the time that the occupant has last adjusted the temperature (step **88**), in which case the power to the Peltier modules is reduced to 25 percent (step **90**). It is desirable to reduce the power to the Peltier modules under such circumstances to prevent over cooling of the occupant's back, which has been shown to cause the occupant discomfort after use of the VTS. If the temperature is not below 303° K., however, the power to the Peltier modules is maintained as indicated by the occupant controls (step **86**).

When the temperature switch is positioned to one of the four heating modes the LED lamp **62** registers a red color (step **92**). If the temperature is below about 339° K. (step **94**) the power to the Peltier modules remains on (step **96**). If the temperature is in the range of from 339° K. to 349° K. (step **92**) the power to the Peltier modules is reduced to 25 percent until the temperature is below 339° K. (step **98**). Reducing the power to the Peltier modules in this situation is desired to prevent the Peltier modules from overheating.

If the temperature of the main heat exchanger side of the Peltier modules is below either below 200° K. or above 349° K. (step **100**), regardless of whether the Peltier modules are in the heating or cooling mode, the controller deactivates the Peltier modules (step **76**) and maintains the operation of the main exchanger fans and waste exchanger fans. The occurrence of either of the above temperature conditions indicates a system malfunction. In this condition the LED lamp **62** registers a orange color, indicating a system malfunction.

The first embodiment comprises conditioned air temperature sensors **102** and **104** positioned in the air flow of the temperature conditioned air passing to the seat, back and seat bottom, respectively, as shown in FIG. **2**. The conditioned air temperature sensors are electrically connected to the controller **64**. The temperature climate control algorithm described above and illustrated in FIG. **3** is configured to deactivate the Peltier modules in the event that the temperature of the conditioned air is greater than about 325° K. or below about 297° K. While the Peltier modules are deactivated the main exchanger fans continue to run.

FIG. **4** shows a second embodiment of the TCCS according to the practice of the present invention. The second embodiment is similar to the first embodiment in all respects, except for the addition of at least one ambient air temperature sensor **102** to monitor the temperature of the air outside of the VTS surrounding the occupant. The temperature sensor is electrically connected to relay ambient air temperature information to the controller **64**. More than one ambient air temperature sensor may be used, each being positioned at different locations in the environment surrounding the occupant, to provide an ambient air temperature profile to the controller.

The second embodiment of the TCCS also differs from the first preferred embodiment in that the fan speed and air temperature for the seat back heat pump **26** and the seat bottom heat pump **28** can each be manually adjusted independently by using a separate seat back fan switch **104** and seat bottom fan switch **106**, and a separate seat back temperature switch **108** and seat bottom temperature switch **110**. The fan switches **104** and **106** and the temperature switches **108** and **110** in the second embodiment are the same as those previously described in the first embodiment. Alternatively, the TCCS may be configured having a single fan switch (not shown) to control the speed of fans **42** and **44** and two temperature switches (not shown) to control the power to each heap pump **26** and **28** independently. The TCCS may also be configured having a single temperature switch (not shown) to control the power of heat pumps **26** and **28** simultaneously and two fan switches to control the speed of each fan **42** and **44** independently.

LED lamps **112** and **114** are located near each temperature switch to indicate the mode of operation selected for each heat pump, e.g., in the off position the LED lamps are off, when both heat pumps are in the cooling mode the LED lamps register a green color, when both heat pumps are in the heating mode the LED lamps register a red color, when there is a temperature error or Peltier module malfunction in either heat pump the LED lamps fast cycle red and green, registering an orange color.

Configuring the manual fan speed and temperature switches in this manner allows the occupant the ability to operate the seat back **12** of the VTS at a different conditions than the seat bottom **14**. This may be desirable where a medical condition or injury requires that a particular portion of the occupant's body be maintained at a temperature different from the remaining portion of the occupant, e.g., where a leg injury requires cooling air in the seat bottom of the VTS and the ambient temperature dictates that heated air pass through the seat back for maximum occupant comfort.

Like the first embodiment, the electrical feeds to and/or outlets from the fan switches **104** and **106**, temperature switches **108** and **110**, main exchanger fans **42** and **44**, waste exchanger fans **50** and **52**, Peltier thermoelectric modules **30** and **32**, temperature sensors **54** and **56**, LED lamps **112** and **114**, and the ambient air temperature sensor **102** are routed to the controller **64**.

FIG. **5** is a flow chart illustrating a temperature climate control algorithm for the second embodiment of the TCCS shown in FIG. **4**. The control algorithm is similar to that previously described above and shown in FIG. **3**, except for the additional temperature inputs from the ambient temperature sensor (step **116**) and the conditioned air sensor, and except when the Peltier modules are being operated in the cooling mode and the temperature of the conditioned air from the seat back heat pump **26** is below about 310° K. (step **119**). When the conditioned air temperature is below about 310° K., if it has been greater than six minutes since the last temperature adjustment by the occupant (step **120**), and the conditioned air temperature of the conditioned is approximately 3° K. or more below the temperature of the ambient air surrounding the occupant (step **122**) , the controller reduces the power to the Peltier modules in the seat back heat pump **26** to approximately 25 percent (step **124**). If the temperature is below about 310° K., but it has either been less than six minutes since the last manual temperature adjustment or the conditioned air temperature is less than 3° K. below the ambient temperature, the power to the Peltier modules in the seat back heat pump remains on at the occupant controlled setting (step **126**).

Like the control algorithm described in FIG. **3**, the reason for reducing the power to the Peltier modules under such conditions is to regulate the amount of cooling air directed to an occupant's back to prevent possible discomfort after using the VTS.

The second embodiment also comprises conditioned air temperature sensors **128** and **130** positioned in the air flow of the temperature conditioned air passing to the seat, back and bottom, respectively, as shown in FIG. **4**. The conditioned air temperature sensors are electrically connected to the controller **64**. The temperature climate control algorithm described above and illustrated in FIG. **5** is configured to deactivate the Peltier modules in the event that the temperature of the conditioned air directed to the occupant is greater than about 325° K. or below about 297° K. While the Peltier modules are deactivated the main exchanger fans continue to run.

FIG. **6** shows a third embodiment of the TCCS according to the practice of this invention. The third embodiment is similar to the first embodiment in all respects except for two. One is the addition of at least one ambient air temperature sensor **132** to monitor the temperature of the air outside of the VTS surrounding the occupant. The temperature sensor is electrically connected to feed temperature information to the controller **64**. More than one ambient air temperature sensor may be used, each being positioned at different locations in the environment surrounding the occupant, to provide an ambient air temperature profile to the controller.

The second difference in the third embodiment of the TCCS is that only a single heat pump **134** is used to provide temperature conditioned air to both the seat back **12** and the seat bottom **14**. The single heat pump is similar to the seat back heat pump **26** and seat bottom heat pump **28** previously described in the first embodiment in that it comprises a main heat exchanger **136**, a main exchanger fan **138**, a waste heat exchanger **140**, a waste exchanger fan **142** and a Peltier module temperature sensor **143**. However, instead of three Peltier thermoelectric modules, the single heat pump **134** comprises four Peltier thermoelectric modules **144**. The temperature conditioned air from the main heat exchanger is passed to the seat back **12** and seat bottom **14** of the VTS by an air manifold **146** connected at one end to the outlet of the main heat exchanger **136** and at the other end to the seat back air inlet **24** and seat bottom air inlet **22**. Alternatively, the third embodiment of the TCCS may comprise a double heat pump arrangement similar to that previously described in the first embodiment.

The third embodiment of the TCCS also differs from the first embodiment in that the main exchanger fan speed and the heat pump air temperature are not manually adjustable by the occupant. Rather, the fan speed and the air temperature are controlled automatically by the controller **64**. Additionally, an occupant presence switch **148** is located within the VTS that is activated upon the presence of an occupant in the seat. The occupant presence switch may comprise a weight sensitive switch and the like located in the seat back or seat bottom. In a preferred embodiment, the occupant presence switch is located in the seat bottom and is electrically connected to the controller to relay the presence of an occupant. The use of a occupant presence switch to control the activation of the VTS is desired for purposes of conserving electricity when the VTS is not occupied and when it is not practical or desirable to give individual control over the seats, e.g., in bus passenger seating applications.

FIG. **7** is a flow chart illustrating a temperature climate control algorithm for the third embodiment of the TCCS as

shown in FIG. **6**. The activation of the main exchanger fan **138** is controlled by an occupant sitting in the VTS (step **150**), which activates the occupant presence switch, and the ambient conditions inside the vehicle as transmitted to the controller by the ambient temperature sensors (step **148**). To ensure a rapid temperature response upon placement of an occupant in the VTS, the controller pulses electrical power to the Peltier modules in the absence of an occupant at a steady state of voltage in the range of from 0.5 to 1 volt (step **152**). The voltage that is actually applied during the duty cycle may be six or twelve volts. By maintaining a slow continuous pulse of power to the Peltier modules the transient time for achieving the desired temperature of conditioned air upon the presence of an occupant in the VTS is greatly minimized.

Once an occupant is seated in the VTS, the particular main fan speed and Peltier operating mode selected by the controller is dependent upon the ambient temperature surrounding the VTS occupant. When the ambient temperature is less than about 286° K. (step **154**) the controller selects a heating mode of operation and passes 100 percent power to the Peltier modules and operates the main exchanger fan at medium speed (step **156**). Upon the activation of the main exchanger fan the waste exchanger fan is also activated at high speed.

When the ambient temperature is between 286° K. and 290° K. (step **158**) the controller selects a heating mode of operation and passes 75 percent power to the Peltier modules and operates the main exchanger fan at medium speed (step **160**). When the temperature is between 290° K. and 293° K. (step **162**) the controller selects a heating mode of operation and passes 25 percent power to the Peltier modules and operates the main exchanger fan at a medium speed (step **164**).

When the ambient temperature is between 293° K. and 297° K. the (step **166**) the controller pulses power to the Peltier modules at a steady state of approximately 0.5 volts and deactivates the main exchanger fan (step **168**).

When the ambient temperature is between 297° K. and 297° K. (step **170**) the controller selects a cooling mode of operation and passes 50 percent power to the Peltier modules and operates the main exchanger fan at medium speed (step **172**). When the ambient temperature is between 300° K. and 302° K. (step **174**) the controller selects a cooling mode of operation and passes 50 percent power to the Peltier modules and operates the main exchanger fan at high speed (step **176**). When the ambient temperature is above 302° K. (step **178**) the controller selects a cooling mode of operation and passes 100 percent power to the Peltier modules and operates the main exchanger fan at high sped (step **180**).

In either the heating mode of operation (ambient temperatures up to 293° K.) or the cooling mode of operation (ambient temperatures above 297° K.), a Peltier modules temperature (step **182**) below 200° K. or above 394° K. (step **184**) causes the controller to deactivate the Peltier modules and maintain the operation of the main exchanger fan and waste exchanger fan (Step **186**). Either of the above conditions indicate a system malfunction.

The third embodiment also includes a conditioned air temperature sensor **188** positioned in the air flow of the temperature conditioned air passing to the seat, as shown in FIG. **6**. The conditioned air temperature sensor is electrically connected to the controller **64**. The temperature climate control algorithm described above and illustrated in FIG. **7** is configured to deactivate the Peltier modules **144** in the event that the temperature of the conditioned air passing to the seat and to the occupant is greater than about 325° K. or below about 297° K. While the Peltier modules are deactivated the main exchanger fans continue to run.

The third embodiment of the TCCS as specifically described above and illustrated in FIG. **6** is used for controlling multiple VTSs in multi-occupant applications such as buses, trains, planes and the like. In such an application the main exchanger fan, waste exchanger fan, Peltier modules, temperature sensor, and weight sensitive switch from each VTS are electrically connected to a common controller. Multiple ambient air temperature sensors may be placed at different locations within the vehicle to provide an accurate temperature profile throughout the interior of the vehicle. The common controller is configured to accommodate inputs from the multiple ambient air temperature sensors. The common controller may be configured to control the main fan speed and mode of operation for the Peltier modules in the same manner as that specifically described above and illustrated in FIG. **7**, taking into account the possibility of different ambient temperature zones within the vehicle surrounding each VTS.

Although limited embodiments of the temperature climate control system have been described and illustrated herein, many modifications and variations will be apparent to those skilled in the art. For example, it is to be understood within the scope of this invention that a temperature climate control system according to the present invention may comprise means for automatically adjusting the flow of temperature conditioned air from a single heat pump to the seat back or the seat bottom.

FIG. **8** illustrates an alternative embodiment of the third embodiment of the TCCS, incorporating the use of valves **190** and **192** placed in the air manifold **146** leading to the seat back and the seat bottom, respectively. The valves are activated electrically by a controller **64** according to a predetermined control algorithm. The control algorithm may be the same as that specifically described above and illustrated in FIG. **7** for the third embodiment, with the addition that controller limits the flow of cooling air to the seat back by closing valve **190** in the event that the occupant receives too much cooling air over a period of time. This embodiment would help eliminate the occurrence of occupant discomfort after using the VTS.

In addition to the embodiments of the TCCS specifically described and illustrated, it is to be understood that such the TCCS may incorporate input from an energy management system, such as that used in electric powered vehicles. In specific embodiments, the TCCS is configured to accept an inhibit signal from such an energy management system. The inhibit signal is typically activated by a vehicle's energy management system under particular conditions of operation when an additional amount of energy is required or when the battery is being discharged to rapidly, such as during hard acceleration, when climbing a hill, or when the battery is weak or is approaching its minimum discharge voltage. The temperature climate control algorithm according to the present invention can be configured to deactivate the Peltier modules, the main exchanger fans, and the waste exchanger fans upon activation of the inhibit signal.

Accordingly, it is to be understood that, within the scope of the appended claims, the temperature climate control system according to principles of this invention may be embodied other than as specifically described herein.

What is claimed is:

1. A system for controlling the temperature climate in a variable temperature occupant seat comprising:

an occupant seat having means for distributing temperature conditioned air through the seat to increase a seat occupant's thermal comfort;

at least one heat pump connected to the seat by a[n air] conduit for providing temperature [conditioning] *conditioned* air to the seat[, the heat pump comprising:

at least one thermoelectric module for temperature conditioning the air];

at least one fan for passing the temperature conditioned air [through the seat to an occupant and for removing unwanted thermal energy from the thermoelectric module] *to the seat*;

a controller for activating and regulating the operation of the [thermoelectric module and] fan [of at least one heat pump] independent of occupant input after a desired mode of operation has been selected;

means for automatically operating the controller to [optimize] *change* system response, to provide [maximum] thermal comfort to the seated occupant, and to control cooling functions of the system to [minimize] *reduce* occupant discomfort and adverse physiological response; and

an indicator switch attached to the seat to detect the presence of an occupant, the indicator switch being electrically connected to the controller.

2. The system as recited in claim **1**, comprising a temperature sensor [attached to the heat pump to sense the operation of the heat pump, the temperature sensor being electrically connected to the controller to facilitate controlling the operation of the heat pump.] *with at least one of a sensor sensing the temperature of the heat pump, a sensor sensing the temperature of the seat, or a sensor sensing the ambient air temperature near the seat.*

3. The system as recited in claim [**2**]*1*, [comprising] *wherein the sensor comprises* at least one temperature sensor positioned in the flow path of the temperature conditioned [air] *fluid*.

4. The system as recited in claim **1**, comprising more than one seat, the operation of each heat pump for each seat being automatically regulated by a single controller *capable of providing different comfort control to different seats.*

5. A method for controlling the temperature climate in a variable temperature occupant seat, the method comprising the steps of:

activating at least one thermoelectric module to provide temperature conditioned air [to be distributed through a variable temperature seat];

activating at least one electric fan for passing the temperature conditioned air [through means inside of] *to* the variable temperature seat;

sensing a system temperature and relaying the temperature information to a controller;

automatically adjusting the electrical power to the thermoelectric module when the thermoelectric module is operated in a cooling mode and when the temperature of the temperature conditioned air is below a minimum cooling temperature a predetermined amount of time after the cooling mode has been selected; and

automatically activating each fan and each thermoelectric module by occupying the seat and automatically deactivating each fan and the thermoelectric module by vacating the seat.

6. The method as recited in claim **5**, comprising manually adjusting the speed of each electric fan and mode of operation for each thermoelectric module to provide a desired flow rate and temperature of conditioned air directed to the occupant.

7. A method for controlling the temperature climate in a variable temperature occupant seat, the method comprising the steps of:

sensing whether the seat is occupied and relaying the information to a controller configured to automatically regulate the operation of one or more thermoelectric modules and fans;

activating at least one thermoelectric module in response to sensing occupancy of the seat to provide temperature conditioned air;

activating at least one fan [for passing] *to pass* the temperature conditioned air [through air channels inside of] *to* the variable temperature seat;

sensing a system temperature and relaying the temperature information to the controller; and

automatically reducing electrical power to the thermoelectric modules when operated in a cooling mode after the temperature of the temperature conditioned air is below a minimum cooling temperature and after a maximum amount of time has passed since the system was placed in a cooling mode of operation.

8. The method as recited in claim **7**, [further comprising the steps of reducing electrical power to the thermoelectric modules when operated in a cooling mode, the operating temperature is below a predetermined cooling temperature, a predetermined amount of time has passed since the temperature was last adjusted by the occupant, and the temperature of the conditioned air directed to an occupant is a cooler by a predetermined amount than the ambient temperature surrounding the occupant] *wherein the step of automatically changing the electrical power comprises the step of changing the power based on signals correlated to temperature and to elapsed time.*

9. A method for controlling the temperature climate in a variable controlled occupant seat, the method comprising the steps of:

activating a number of thermoelectric modules [for temperature conditioning air to be passed and distributed through a variable temperature seat] *to generate temperature conditioned air;*

[activating at least one fan for passing the temperature conditioned air through air channels inside of the variable temperature seat to an occupant] *communicating the temperature conditioned air to the occupant seat by at least one fan; and;*

sensing [the] *a control* temperature [of the thermoelectric modules] and relaying *information correlated to* the temperature [information] to a controller configured to automatically deactivate the operation of the thermoelectric modules and [fans] *the at least one fan* when the temperature [is below approximately 200° K. and above approximately 349° K.;

automatically decreasing the electrical power to the thermoelectric modules when the thermoelectric modules are operated in a cooling mode, the temperature is below approximately 303° K., and it has been more than 6 minutes since the operating mode was last adjusted by the occupant; and

automatically decreasing the electrical power to the thermoelectric modules when the thermoelectric modules are operated in a heating mode and the temperature is in the range of from 339° K. to 349° K] *reaches a predetermined limit for a predetermined time to prevent damage to one of the occupant seat or a seat occupant.*

10. The method as recited in claim **9**, [comprising sensing] *wherein the control temperature comprises at least one*

of the temperature of the conditioned air directed to the occupant and the temperature of the ambient air surrounding the occupant [and relaying the temperature information to the controller].

11. The method as recited in claim **10**, comprising automatically [decreasing] *changing* the electrical power to the thermoelectric modules when the thermoelectric modules are operated in a cooling mode, the temperature is below approximately 303° K., it has been more than 6 minutes since a the operating mode was last adjusted by the occupant[, and the temperature of the conditioned air is more than 3° K. less than the temperature of the ambient air].

12. A system for controlling the temperature climate in a variable temperature occupant seat comprising:

an occupant seat having [means] *at least one conduit configured* to distribute *a sufficient amount of* temperature conditioned air through the seat [and the temperature conditioned air through the seat for the purpose of increasing] *to increase* a seat occupant's thermal comfort;

at least one heat pump for providing temperature conditioned air, each heat pump being [connected to] *in fluid communication with the conduit in* the seat [by an air conduit] and including one or more fan*s* and one or more thermoelectric module*s*;

a controller [for activating and regulating the operation of each] *in electrical communication with the* heat pump [to produce] *and fan and controlled to provide* temperature conditioned air [at a temperature and fan speed to maximize] *to increase* the thermal comfort of [the] *a* seated occupant;

at least one [temperature] sensor for monitoring the operation of at least one heat pump, [the temperature sensor being electrically connected to the controller] *or monitoring the temperature of the air passing through the heat pump, or monitoring ambient air temperature and providing a signal correlated to that operation or monitored temperature to the controller*;

means for automatically operating the controller to [optimize system response, to] provide [maximum] thermal comfort to the seated occupant, and to control heating and cooling functions of the system to [minimize] *reduce* occupant discomfort and adverse physiological response; and

an indicator for detecting the presence of the seat occupant, the indicator being electrically connected to the controller.

13. A system for controlling the temperature climate in a variable temperature occupant seat comprising:

an occupant seat having [means] *at least one distribution conduit configured* to distribute temperature conditioned air through the seat [and the temperature conditioned air through the seat for the purpose of increasing] *to increase* a seat occupant's thermal comfort;

at least one heat pump for providing temperature conditioned air *from the heat pump to the distribution conduit*, each heat pump [being connected to the seat by an air conduit and] including one or more fan*s* and one or more thermoelectric module*s*;

a controller for activating and regulating the operation of each heat pump to produce temperature conditioned air at a temperature and fan speed to [maximize] *adjust* the thermal comfort of the seated occupant;

at least one temperature sensor [for monitoring the operation of at least one heat pump, the temperature sensor being] electrically connected to the controller; and

means for automatically operating the controller to [optimize] *vary the* system response, to provide [maximum] thermal comfort to the seated occupant, and to control heating and cooling functions of the system, to [minimize] *reduce* occupant discomfort and adverse physiological response, wherein the means for automatically operating the controller reduces the cooling functions of the system when the temperature of the temperature conditioned air is below a minimum cooling temperature and after a maximum amount of time has passed since the system was placed in a cooling mode of operation.

14. The system as recited in claim **13**, wherein the [reduction in cooling functions] *variation in temperature conditioned air* is achieved by [reducing power] *changing voltage* to the thermoelectric module.

15. The system as recited in claim **13**, wherein the [reduction in cooling functions] *variation in temperature conditioned air* is achieved by [reducing] changing power to *at least one of* the thermoelectric module and [to] the fan.

16. A system for controlling the temperature climate in a variable temperature occupant seat comprising:

an occupant seat having means for distributing temperature conditioned air through the seat to increase a seat occupant's thermal comfort;

at least one heat pump [connected to the seat by an air conduit for] providing temperature conditioning air to the seat[, each heat pump comprising:];

[at least one thermoelectric module for temperature conditioning the air;]

at least one fan [for passing] *positioned to move* the temperature conditioned air through the [seat to an occupant and for removing unwanted thermal energy from the thermoelectric module] *conduit*;

a controller for activating and regulating the operation of the [thermoelectric module and fans of each] heat pump independent of occupant input after a desired mode of operation has been selected;

means for automatically operating the controller to optimize system response, to provide maximum thermal comfort to the seated occupant, and to control *heating and* cooling functions of the system, to [minimize] *reduce* occupant discomfort and adverse physiological response, wherein the means for automatically operating the controller reduces the cooling functions of the system when the temperature of the temperature conditioned air is below a minimum cooling temperature and after a maximum amount of time has passed since the system was placed in a cooling mode of operation.

17. A system for controlling the temperature climate in a variable temperature occupant seat comprising:

an occupant seat comprising a seat bottom and a seat back portion each having [means for distributing] *an air distribution conduit sized and located to distribute* temperature conditioned air through the seat and direct[ing] it to an occupant;

a seat back heat pump for conditioning the temperature of the air and passing the air through an air conduit to the seat back[, the seat back heat pump comprising a main exchanger fan and at least one thermoelectric module];

a seat bottom heat pump for conditioning the temperature of the air and passing the air through an air conduit to the seat bottom[, the seat bottom heat pump comprising a main exchanger fan and at least one thermoelectric module];

at least one fan arranged to move air from at least one of the heat pumps through the air conduit associated with the respective heat pump;

[a] *at least one* temperature sensor positioned [in each heat pump] *to monitor the temperature of at least one of the ambient air, conditioned air from at least one heat pump, or at least one heat pump*;

a controller [for automatically activating and regulating the speed of the main fans, and automatically selecting the mode of operation for the thermoelectric module in each heat pump] *receiving information from the temperature sensor and configured to automatically activate and regulate at least one of the speed of the fans and the temperature of the air conditioned by at least one of the heat pumps*;

means for automatically operating the controller to optimize system response, to provide maximum thermal comfort to the seated occupant, and to control cooling functions of the system to minimize occupant discomfort and adverse physiological response, wherein the means for automatically operating the controller reduces the cooling functions of the system when the temperature of the temperature conditioned air is below a minimum cooling temperature and after a maximum amount of time has passed since the system was placed in a cooling mode of operation.

18. A system for controlling the temperature climate in a variable temperature occupant seat comprising:

an occupant seat comprising a seat bottom and a seat back portion each having [means for distributing] *a system configured and located to distribute* temperature conditioned air [through] *in* the seat [and directing it to an occupant];

a seat back heat pump [for conditioning the temperature of the air and passing the air through an air conduit to the seat back, the seat back heat pump comprising a main exchanger fan and at least one thermoelectric module] *in fluid communication with a fan arranged to pass temperature conditioned air to the system*;

[a] *at least one* seat bottom heat pump [for conditioning the temperature of the air and passing the air through an air conduit to the seat bottom, the seat bottom heat pump comprising a main exchanger fan and at least one thermoelectric module] *in fluid communication with a fan arranged to pass temperature conditioned air to the system*;

[a] *at least one* temperature sensor positioned [in each heat pump] *to monitor the temperature of at least one of the seat bottom, seat back, ambient air, conditioned air from at least one heat pump, and at least one heat pump*;

a controller [for automatically activating and regulating the speed of the main fans, and automatically selecting the mode of operation for the thermoelectric module in each heat pump] *receiving information from the temperature sensor and configured to automatically activate and regulate at least one of the speed of the fans and the temperature of the air conditioned by at least one of the heat pumps*;

means for automatically operating the controller to optimize system response, to provide maximum thermal comfort to the seated occupant, and to control cooling functions of the system to minimize occupant discomfort and adverse physiological response; and

an indicator for detecting the present of an occupant, the indicator being electrically connected to the [automatic operating means] *controller*.

19. A system as defined in claim 16, wherein the time and power to the controller vary with a temperature signal from the least one temperature sensor.

20. A system as defined in claim 17, wherein the time and power to the controller vary with a temperature signal from the least one temperature sensor.

21. A system as defined in claim 9, further comprising the step of automatically changing the electrical power to the thermoelectric modules when the control temperature reaches a predetermined temperature and/or when a predetermined amount of time has passed.

22. A system for controlling the temperature climate in a variable temperature occupant seat comprising:

an occupant seat having a conduit to distribute temperature conditioned heating or cooling medium to an area of a seat;

at least one heat pump connected to the seat by a conduit for providing a temperature conditioning medium to the conduit in the seat;

at least one fan for passing the temperature conditioned air to the conduit in the seat;

a controller for activating and regulating the operation of the fan independent of occupant input after a desired mode of operation has been selected;

means for automatically operating the controller to change system response, to provide thermal comfort to the seated occupant, and to control cooling functions of the system to reduce occupant discomfort and adverse physiological response; and

an indicator switch located within the seat to detect the presence of an occupant, the indicator switch being electrically connected to the controller.

23. A method for controlling the temperature climate in a variable temperature occupant seat, the method comprising the steps of:

activating at least one thermoelectric module to provide temperature conditioned air;

activating at least one electric fan for passing the temperature conditioned air to the variable temperature seat;

sensing a system temperature and relating the temperature information to a controller;

automatically adjusting the electrical power to the thermoelectric module based upon temperature and elapsed time information to adjust the temperature of the air distributed to the occupant seat; and

automatically activating each fan and each thermoelectric module by occupying the seat and activating a weight-sensitive sensor and automatically deactivating each fan and the thermoelectric module by vacating the seat and deactivating a weight-sensitive sensor.

24. A method for controlling the temperature climate in a variable temperature occupant seat, the method comprising the steps of:

sensing whether the seat is occupied by use of a weight-sensitive sensor and relaying the information to a controller configured to automatically regulate the operation of one or more thermoelectric modules and fans;

activating at least one thermoelectric module in response to sensing the status of the weight-sensitive sensor to provide temperature conditioned air;

activating at least one fan to pass the temperature conditioned air to the variable temperature seat;

sensing a temperature and relaying the temperature information to the controller; and

automatically changing electrical power to the thermoelectric modules, by varying a duty cycle of power to

the modules, when operated in a cooling mode after the temperature of the temperature conditioned air is below a minimum cooling temperature and after a maximum amount of time has passed since the system was placed in a cooling mode of operation.

25. A system for controlling the temperature climate in a variable temperature occupant seat comprising:

an occupant seat having at least one conduit configured to distribute a sufficient amount of temperature conditioned air through the seat to increase a seat occupant's thermal comfort;

at least one heat pump for providing temperature conditioned air, each heat pump being in fluid communication with the conduit in the seat and having a fan to move thermally conditioned air to the conduit in the seat;

a controller in electrical communication with the heat pump and fan and controlled to provide temperature

conditioned air to increase the thermal comfort of a seated occupant;

at least one sensor for monitoring the operation of at least one heat pump, or monitoring the temperature of the air passing through the heat pump, or monitoring ambient air temperature and providing a signal correlated to that operation or monitored temperature to the controller;

means for automatically operating the controller to provide thermal comfort to the seated occupant, and to control heating and cooling functions of the system to reduce occupant discomfort and adverse physiological response; and

an indicator located in the seat for detecting the presence of the seat occupant, the indicator being in communication with the controller.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : RE 38,128 E
DATED : June 3, 2003
INVENTOR(S) : David F. Gallup, David R. Noles and Richard R. Willis

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 14,
Line 46, please replace "one fan; and;" with -- one fan; and --

Column 15,
Line 7, please replace "thermoelectric modules" (second instance) with -- a the operation --

Column 17,
Line 62, please replace "detecting the present" with -- detecting the presence --

Signed and Sealed this

Thirteenth Day of July, 2004

Jon W. Dudas

JON W. DUDAS
Acting Director of the United States Patent and Trademark Office

US005626021A

United States Patent [19]

Karunasiri et al.

[11] Patent Number: 5,626,021

[45] Date of Patent: May 6, 1997

[54] **VARIABLE TEMPERATURE SEAT CLIMATE CONTROL SYSTEM**

[75] Inventors: **Tissa R. Karunasiri**, Van Nuys; **David F. Gallup**, Pasadena; **David R. Noles**, Glendale; **Christian T. Gregory**, Alhambra, all of Calif.

[73] Assignee: **Amerigon, Inc.**, Monrovia, Calif.

[21] Appl. No.: **288,459**

[22] Filed: **Aug. 10, 1994**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 156,052, Nov. 22, 1993, Pat. No. 5,524,439.

[51] **Int. Cl.**[6] **F25B 21/02**

[52] **U.S. Cl.** **62/3.5**; 62/3.61; 236/49.3

[58] **Field of Search** 62/3.3, 3.5, 3.61, 62/261; 236/49.3

[56] **References Cited**

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OTHER PUBLICATIONS

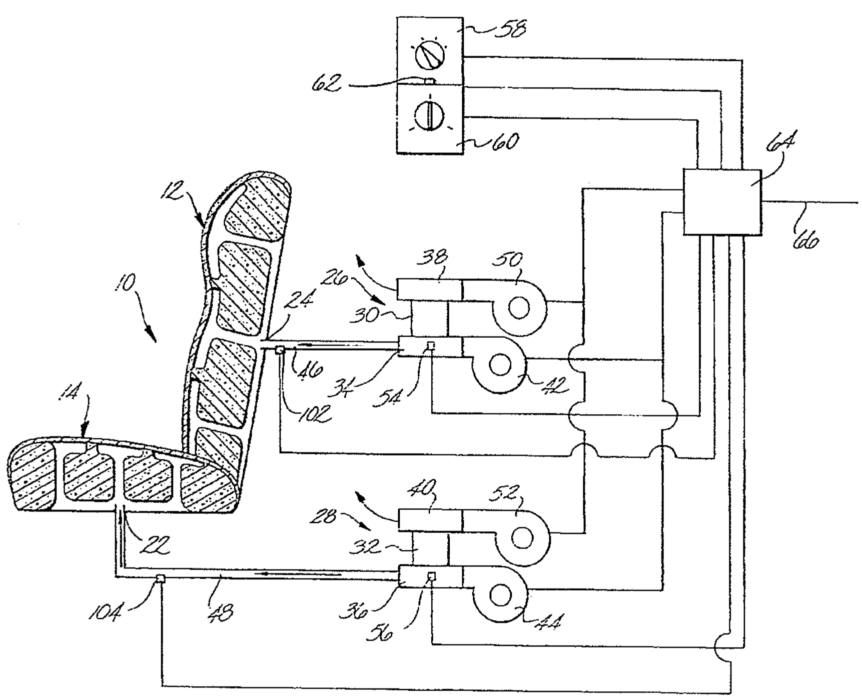
Publication, Abstract *Thermoelectric Air Conditioned Variable Temperature Seat (VTS) & Effect Upon Vehicle Occupant Comfort, Vehicle Energy Efficiency, and Vehicle Environment Compatibility.*

Primary Examiner—William E. Tapolcai
Attorney, Agent, or Firm—Christie, Parker & Hale, LLP

[57] **ABSTRACT**

A temperature climate control system comprises a variable temperature seat, at least one heat pump, at least one heat pump temperature sensor, and a controller. Each heat pump comprises a number of Peltier thermoelectric modules for temperature conditioning the air in a main heat exchanger and a main exchanger fan for passing the conditioned air from the main exchanger to the variable temperature seat. The Peltier modules and each main fan may be manually adjusted via a control switch or a control signal. Additionally, the temperature climate control system may comprise a number of additional temperature sensors to monitor the temperature of the ambient air surrounding the occupant as well as the temperature of the conditioned air directed to the occupant. The controller is configured to automatically regulate the operation of the Peltier modules and/or each main fan according to a temperature climate control logic designed both to maximize occupant comfort during normal operation, and minimize possible equipment damage, occupant discomfort, or occupant injury in the event of a heat pump malfunction.

24 Claims, 15 Drawing Sheets



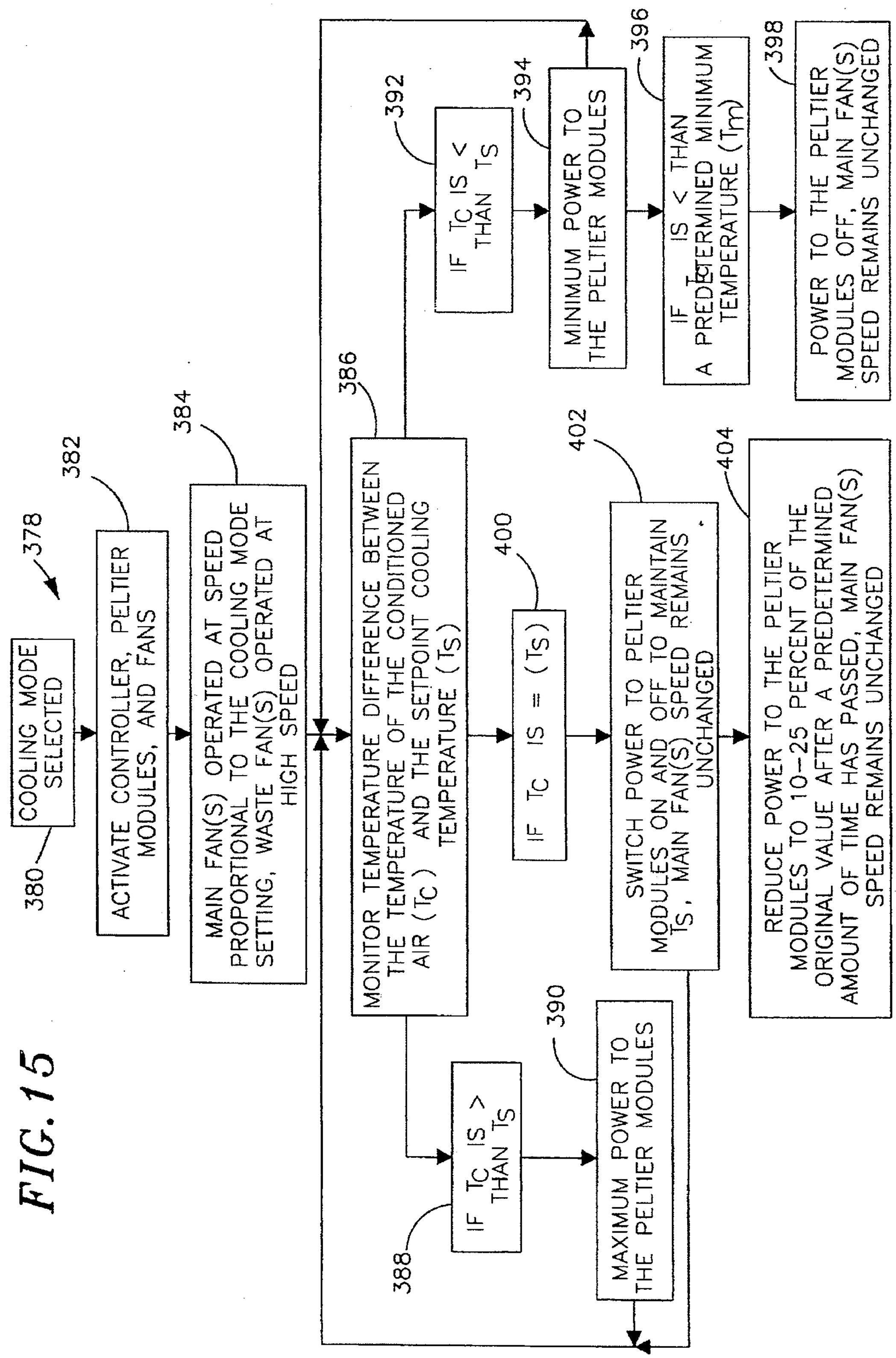

378
COOLING MODE SELECTED
380
ACTIVATE CONTROLLER, PELTIER MODULES, AND FANS
382
MAIN FAN(S) OPERATED AT SPEED PROPORTIONAL TO THE COOLING MODE SETTING, WASTE FAN(S) OPERATED AT HIGH SPEED
384
MONITOR TEMPERATURE DIFFERENCE BETWEEN THE TEMPERATURE OF THE CONDITIONED AIR (TC) AND THE SETPOINT COOLING TEMPERATURE (TS)
386
IF TC IS < THAN TS
392
MINIMUM POWER TO THE PELTIER MODULES
394
IF TC IS < THAN A PREDETERMINED MINIMUM TEMPERATURE (Tm)
396
POWER TO THE PELTIER MODULES OFF, MAIN FAN(S) SPEED REMAINS UNCHANGED
398
IF TC IS = (TS)
400
SWITCH POWER TO PELTIER MODULES ON AND OFF TO MAINTAIN TS, MAIN FAN(S) SPEED REMAINS UNCHANGED
402
REDUCE POWER TO THE PELTIER MODULES TO 10-25 PERCENT OF THE ORIGINAL VALUE AFTER A PREDETERMINED AMOUNT OF TIME HAS PASSED, MAIN FAN(S) SPEED REMAINS UNCHANGED
404
IF TC IS > THAN TS
388
MAXIMUM POWER TO THE PELTIER MODULES
390

FIG. 15

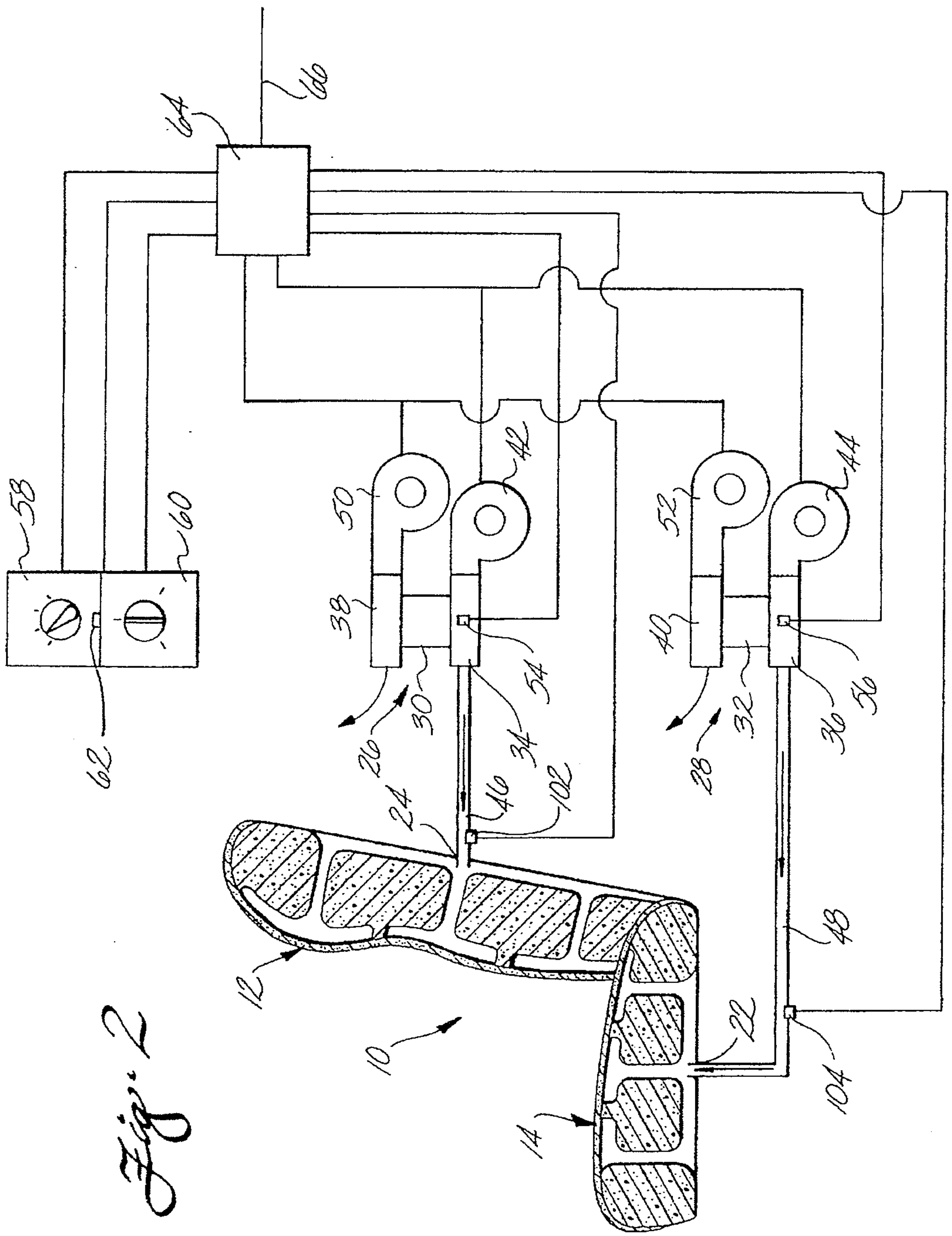

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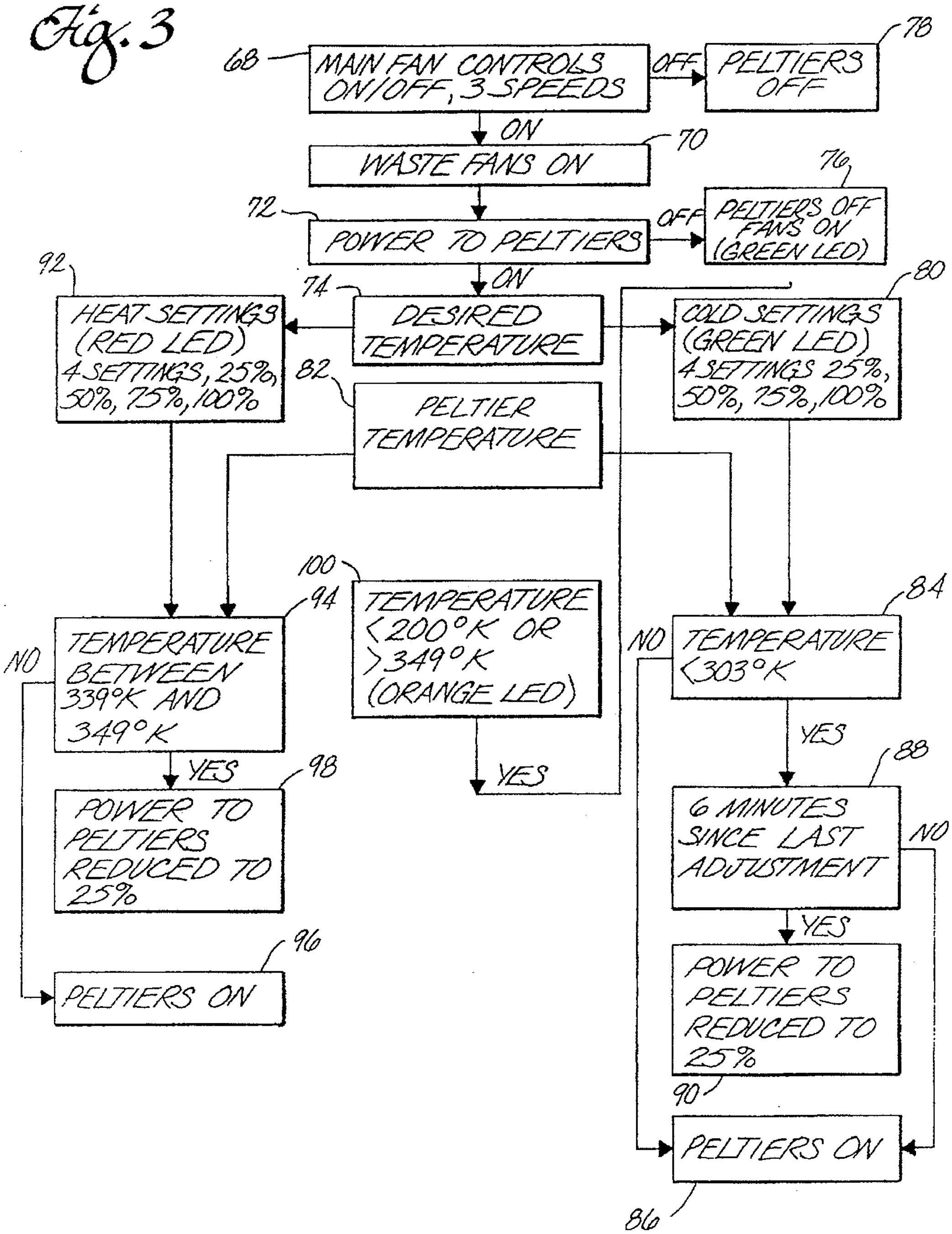
Fig. 2

Fig. 3


68
MAIN FAN CONTROLS ON/OFF, 3 SPEEDS
OFF
PELTIERS OFF
78
ON
WASTE FANS ON
70
72
POWER TO PELTIERS
OFF
PELTIERS OFF FANS ON (GREEN LED)
76
ON
74
DESIRED TEMPERATURE
92
HEAT SETTINGS (RED LED) 4 SETTINGS, 25%, 50%, 75%, 100%
80
COLD SETTINGS (GREEN LED) 4 SETTINGS 25%, 50%, 75%, 100%
82
PELTIER TEMPERATURE
100
94
TEMPERATURE BETWEEN 339°K AND 349°K
NO
YES
98
POWER TO PELTIERS REDUCED TO 25%
96
PELTIERS ON
TEMPERATURE <200°K OR >349°K (ORANGE LED)
YES
84
TEMPERATURE <303°K
NO
YES
88
6 MINUTES SINCE LAST ADJUSTMENT
NO
YES
POWER TO PELTIERS REDUCED TO 25%
90
PELTIERS ON
86

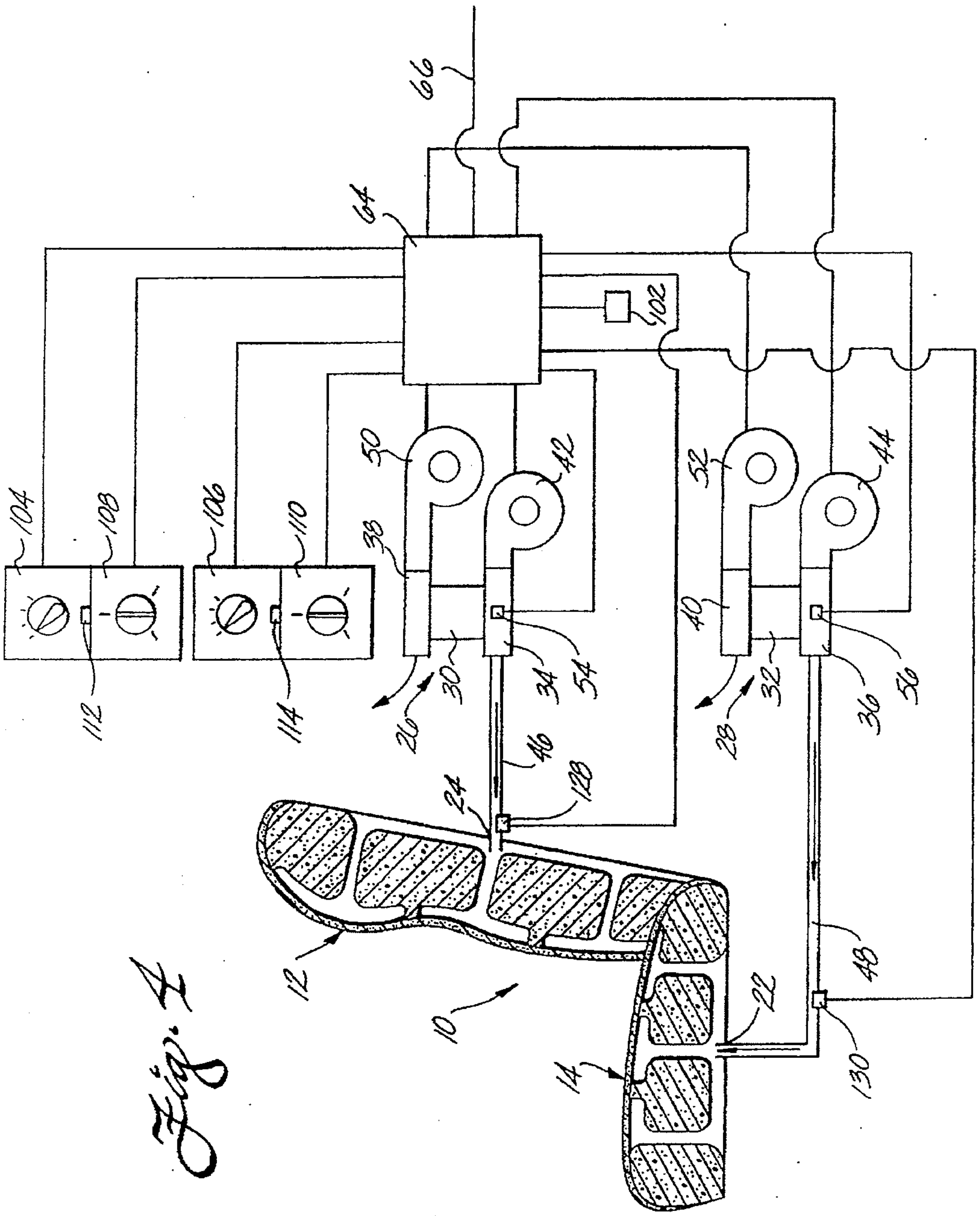

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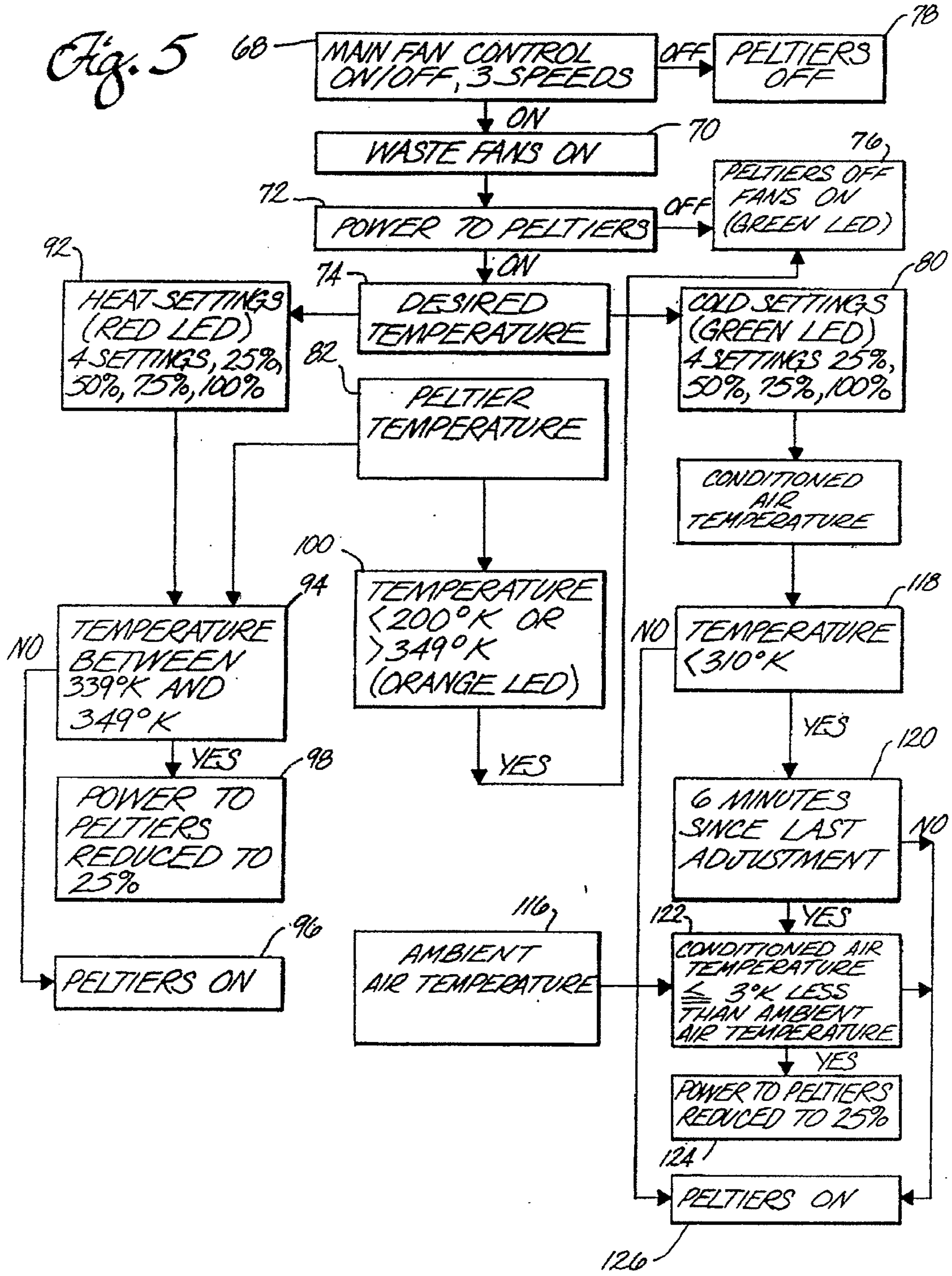
Fig. 4

Fig. 5


68
MAIN FAN CONTROL ON/OFF, 3 SPEEDS
OFF
PELTIERS OFF
78
ON
WASTE FANS ON
70
76
PELTIERS OFF FANS ON (GREEN LED)
72
POWER TO PELTIERS
OFF
ON
74
DESIRED TEMPERATURE
92
HEAT SETTINGS (RED LED) 4 SETTINGS, 25%, 50%, 75%, 100%
80
COLD SETTINGS (GREEN LED) 4 SETTINGS 25%, 50%, 75%, 100%
82
PELTIER TEMPERATURE
CONDITIONED AIR TEMPERATURE
100
TEMPERATURE <200°K OR >349°K (ORANGE LED)
94
TEMPERATURE BETWEEN 339°K AND 349°K
NO
YES
98
POWER TO PELTIERS REDUCED TO 25%
96
PELTIERS ON
YES
118
TEMPERATURE <310°K
NO
YES
120
6 MINUTES SINCE LAST ADJUSTMENT
NO
YES
116
AMBIENT AIR TEMPERATURE
122
CONDITIONED AIR TEMPERATURE ≤ 3°K LESS THAN AMBIENT AIR TEMPERATURE
YES
POWER TO PELTIERS REDUCED TO 25%
124
PELTIERS ON
126

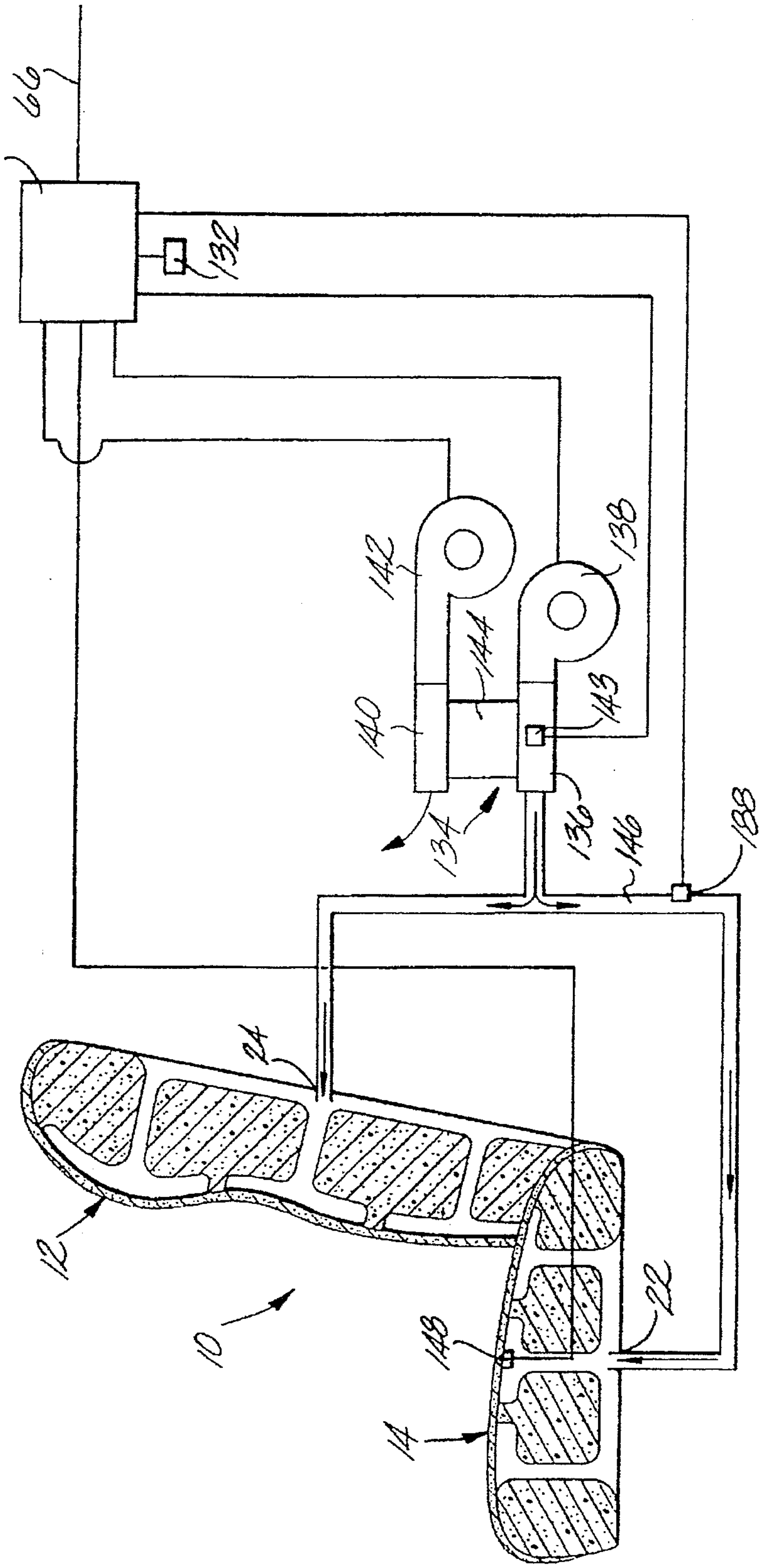
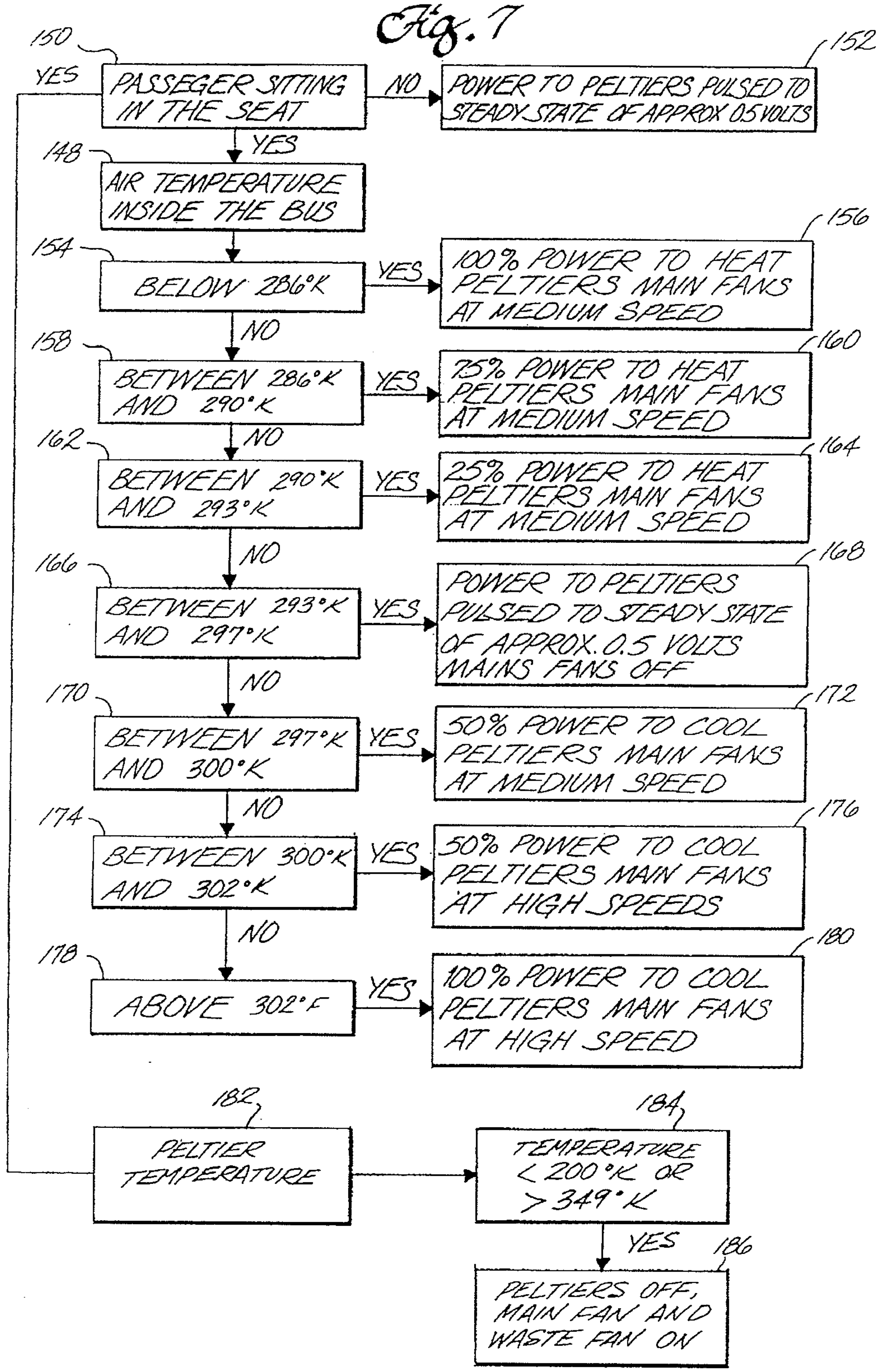


Fig. 6

Fig. 7


150
152
PASSEGER SITTING IN THE SEAT
NO
POWER TO PELTIERS PULSED TO STEADY STATE OF APPROX 0.5 VOLTS
YES
YES
148
AIR TEMPERATURE INSIDE THE BUS
154
BELOW 286°K
YES
156
100% POWER TO HEAT PELTIERS MAIN FANS AT MEDIUM SPEED
NO
158
BETWEEN 286°K AND 290°K
YES
160
75% POWER TO HEAT PELTIERS MAIN FANS AT MEDIUM SPEED
NO
162
BETWEEN 290°K AND 293°K
YES
164
25% POWER TO HEAT PELTIERS MAIN FANS AT MEDIUM SPEED
NO
166
BETWEEN 293°K AND 297°K
YES
168
POWER TO PELTIERS PULSED TO STEADY STATE OF APPROX. 0.5 VOLTS MAINS FANS OFF
NO
170
BETWEEN 297°K AND 300°K
YES
172
50% POWER TO COOL PELTIERS MAIN FANS AT MEDIUM SPEED
NO
174
BETWEEN 300°K AND 302°K
YES
176
50% POWER TO COOL PELTIERS MAIN FANS AT HIGH SPEEDS
NO
178
ABOVE 302°F
YES
180
100% POWER TO COOL PELTIERS MAIN FANS AT HIGH SPEED
182
PELTIER TEMPERATURE
184
TEMPERATURE < 200°K OR > 349°K
YES
186
PELTIERS OFF, MAIN FAN AND WASTE FAN ON

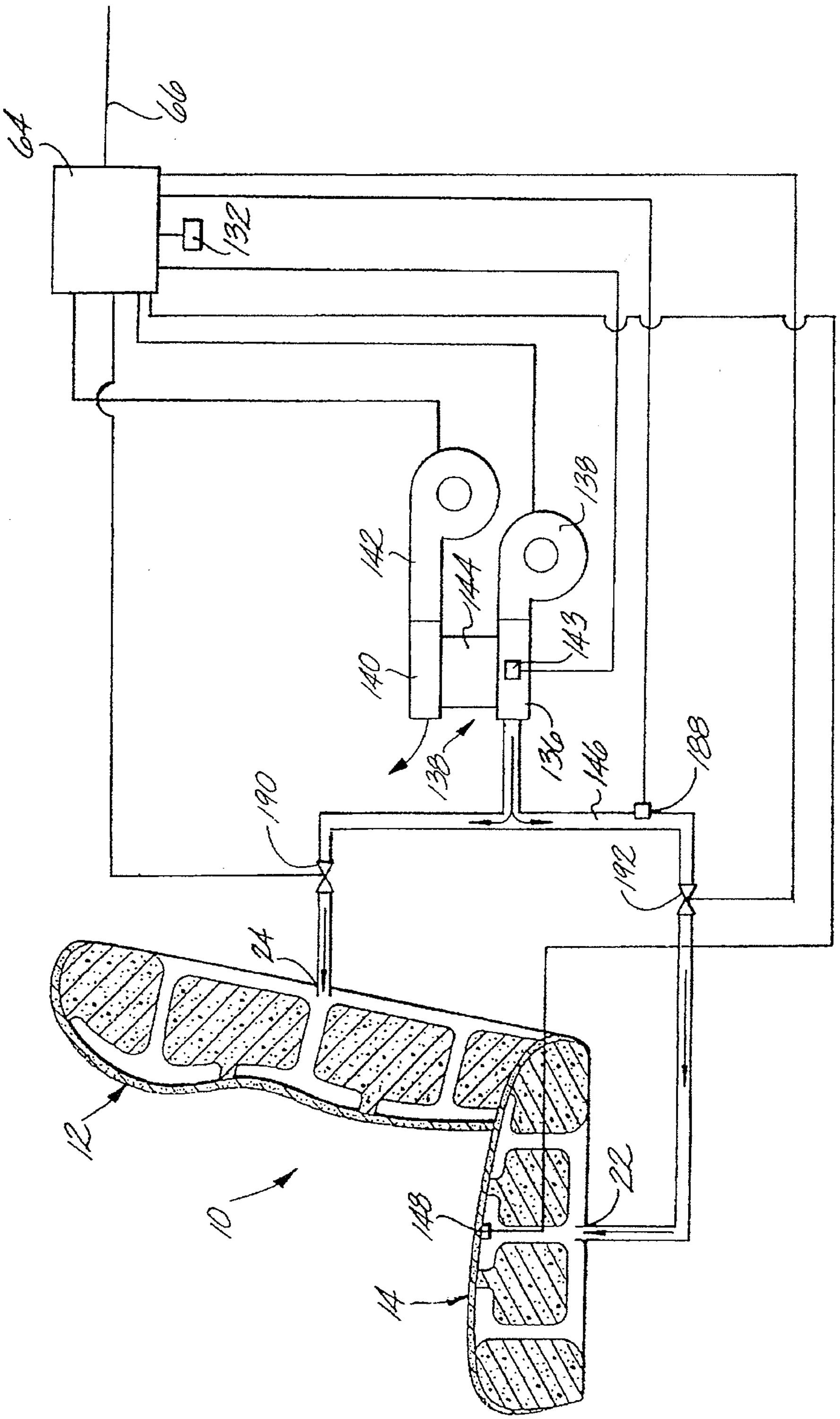


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Fig. 8

FIG. 9

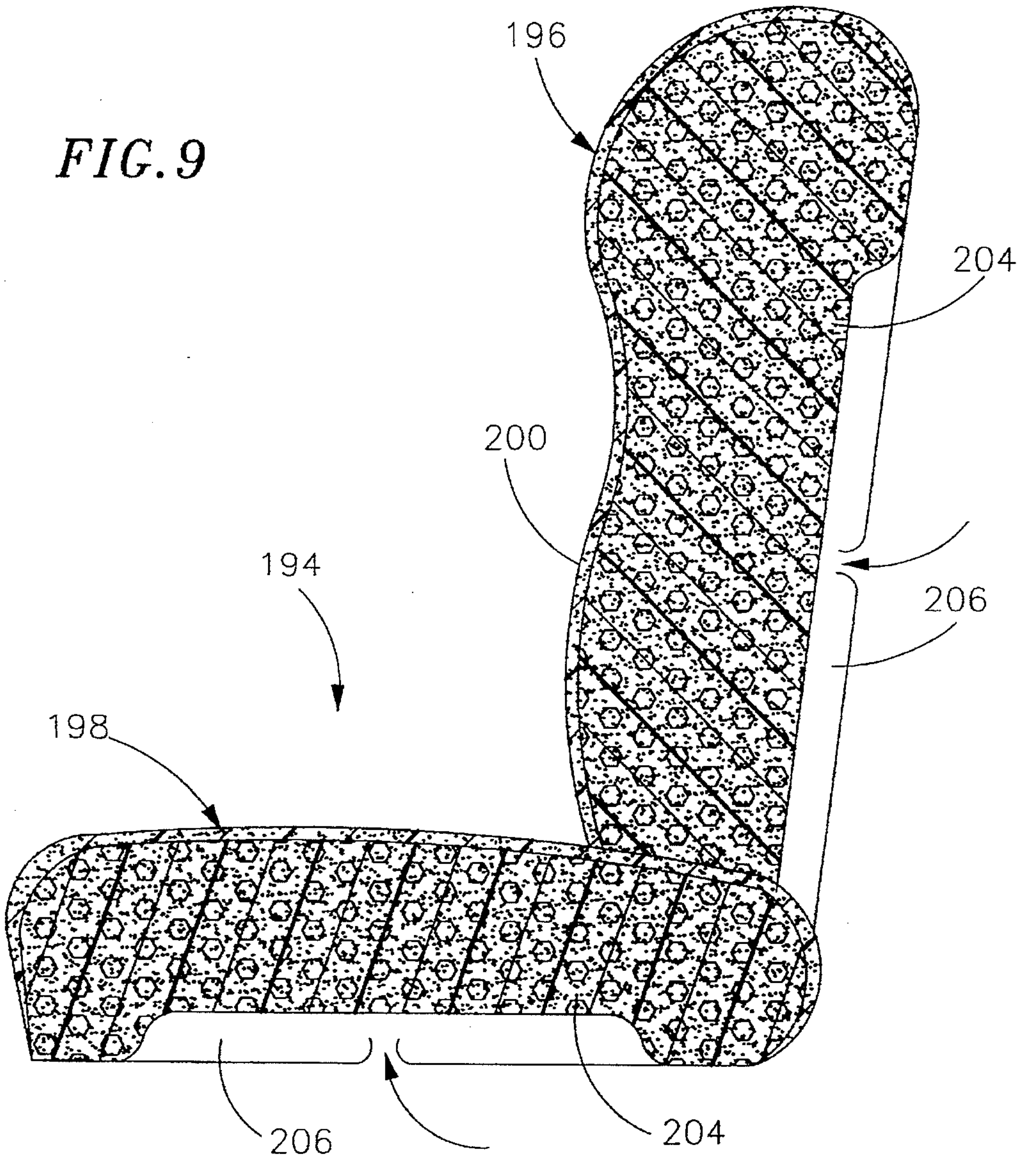
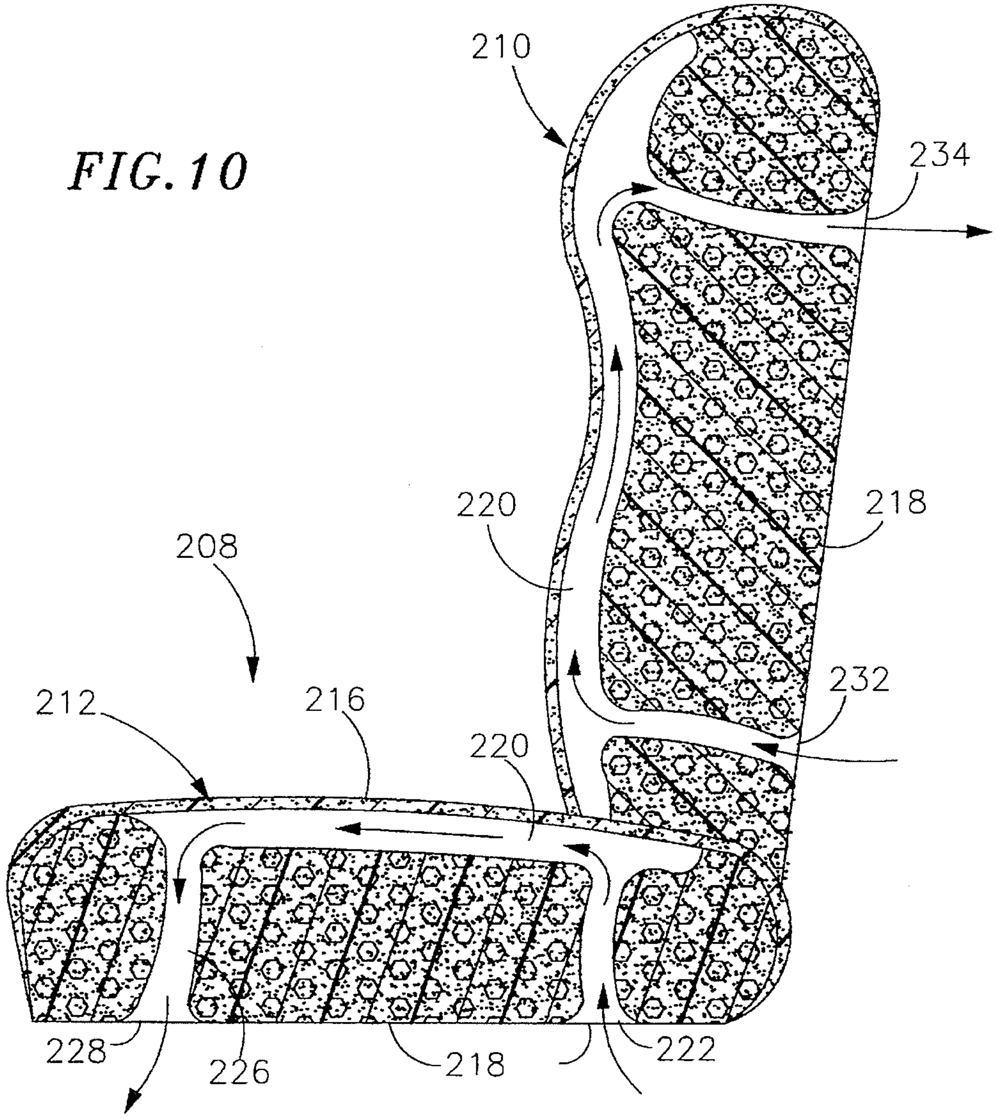
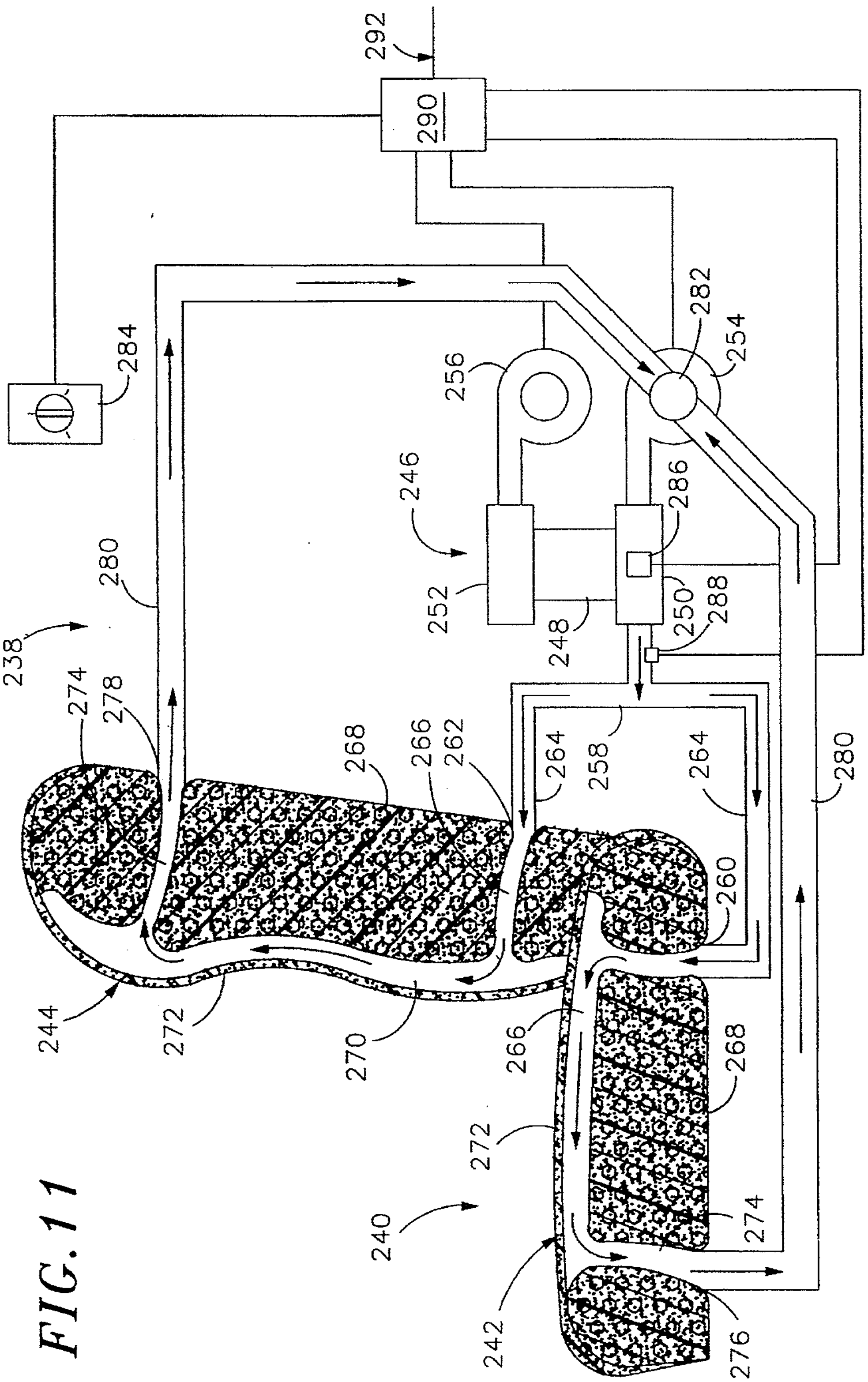


FIG. 10




292
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284
256
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254
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286
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FIG. 11

FIG. 12

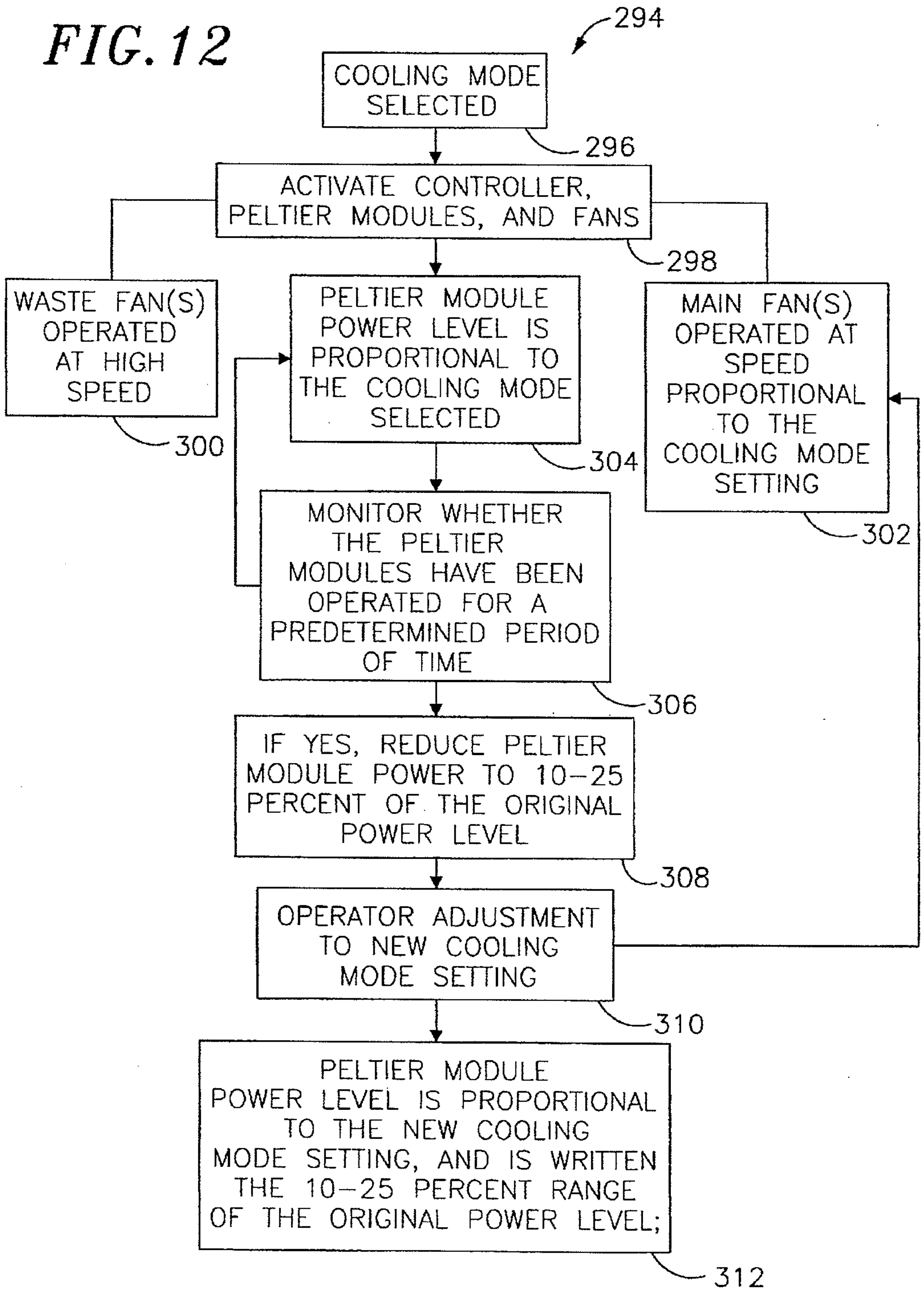
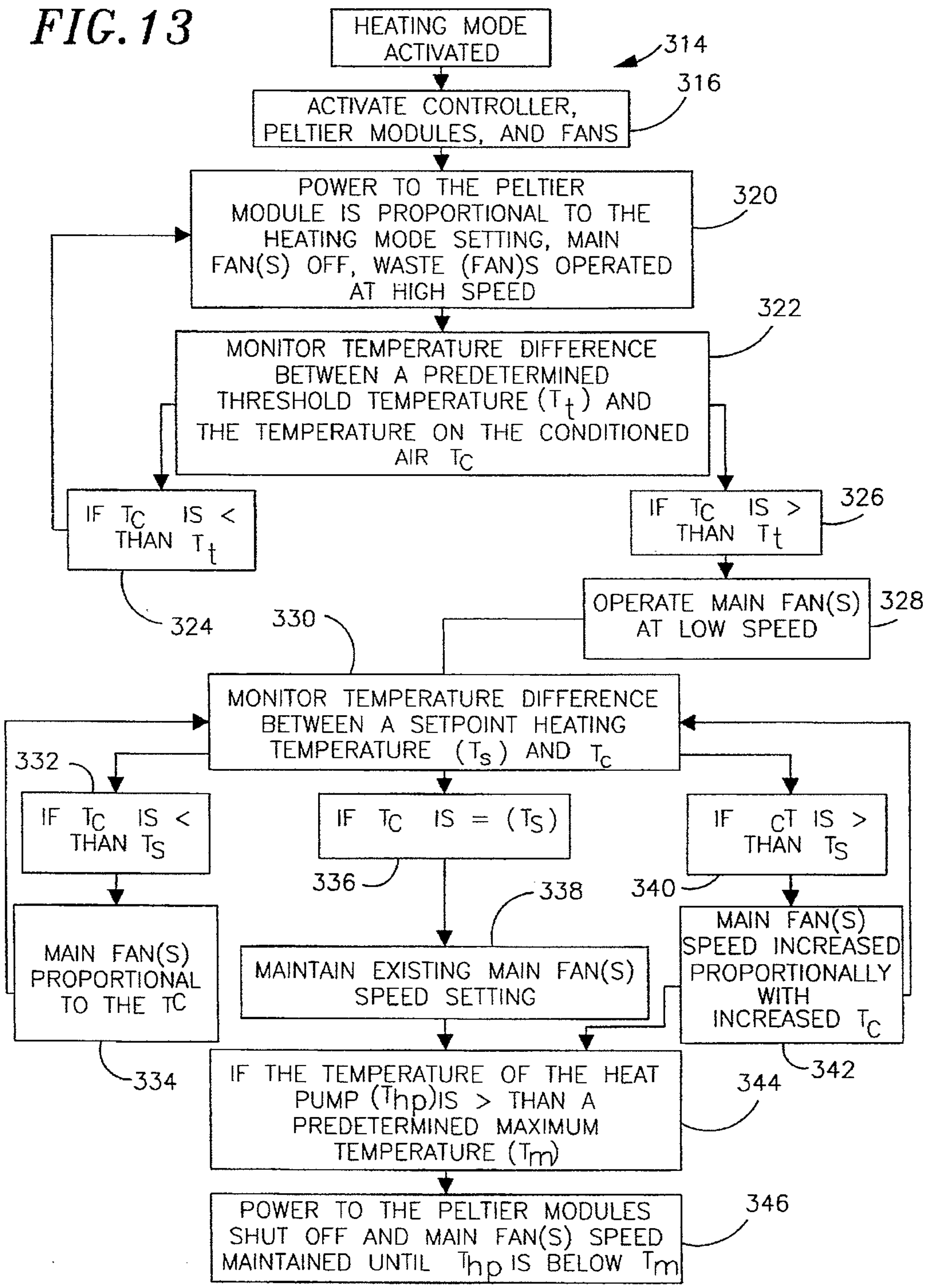

294
COOLING MODE SELECTED
296
ACTIVATE CONTROLLER, PELTIER MODULES, AND FANS
298
WASTE FAN(S) OPERATED AT HIGH SPEED
300
PELTIER MODULE POWER LEVEL IS PROPORTIONAL TO THE COOLING MODE SELECTED
304
MAIN FAN(S) OPERATED AT SPEED PROPORTIONAL TO THE COOLING MODE SETTING
302
MONITOR WHETHER THE PELTIER MODULES HAVE BEEN OPERATED FOR A PREDETERMINED PERIOD OF TIME
306
IF YES, REDUCE PELTIER MODULE POWER TO 10-25 PERCENT OF THE ORIGINAL POWER LEVEL
308
OPERATOR ADJUSTMENT TO NEW COOLING MODE SETTING
310
PELTIER MODULE POWER LEVEL IS PROPORTIONAL TO THE NEW COOLING MODE SETTING, AND IS WRITTEN THE 10-25 PERCENT RANGE OF THE ORIGINAL POWER LEVEL;
312

FIG. 13


HEATING MODE ACTIVATED
314
316
ACTIVATE CONTROLLER, PELTIER MODULES, AND FANS
320
POWER TO THE PELTIER MODULE IS PROPORTIONAL TO THE HEATING MODE SETTING, MAIN FAN(S) OFF, WASTE (FAN)S OPERATED AT HIGH SPEED
322
MONITOR TEMPERATURE DIFFERENCE BETWEEN A PREDETERMINED THRESHOLD TEMPERATURE (T_t) AND THE TEMPERATURE ON THE CONDITIONED AIR T_C
IF T_C IS < THAN T_t
324
IF T_C IS > THAN T_t
326
OPERATE MAIN FAN(S) AT LOW SPEED
328
330
MONITOR TEMPERATURE DIFFERENCE BETWEEN A SETPOINT HEATING TEMPERATURE (T_S) AND T_C
332
IF T_C IS < THAN T_S
IF T_C IS = (T_S)
IF CT IS > THAN T_S
336
338
340
MAIN FAN(S) PROPORTIONAL TO THE TC
MAINTAIN EXISTING MAIN FAN(S) SPEED SETTING
MAIN FAN(S) SPEED INCREASED PROPORTIONALLY WITH INCREASED T_C
334
342
344
IF THE TEMPERATURE OF THE HEAT PUMP (T_{hp})IS > THAN A PREDETERMINED MAXIMUM TEMPERATURE (T_m)
346
POWER TO THE PELTIER MODULES SHUT OFF AND MAIN FAN(S) SPEED MAINTAINED UNTIL T_{hp} IS BELOW T_m

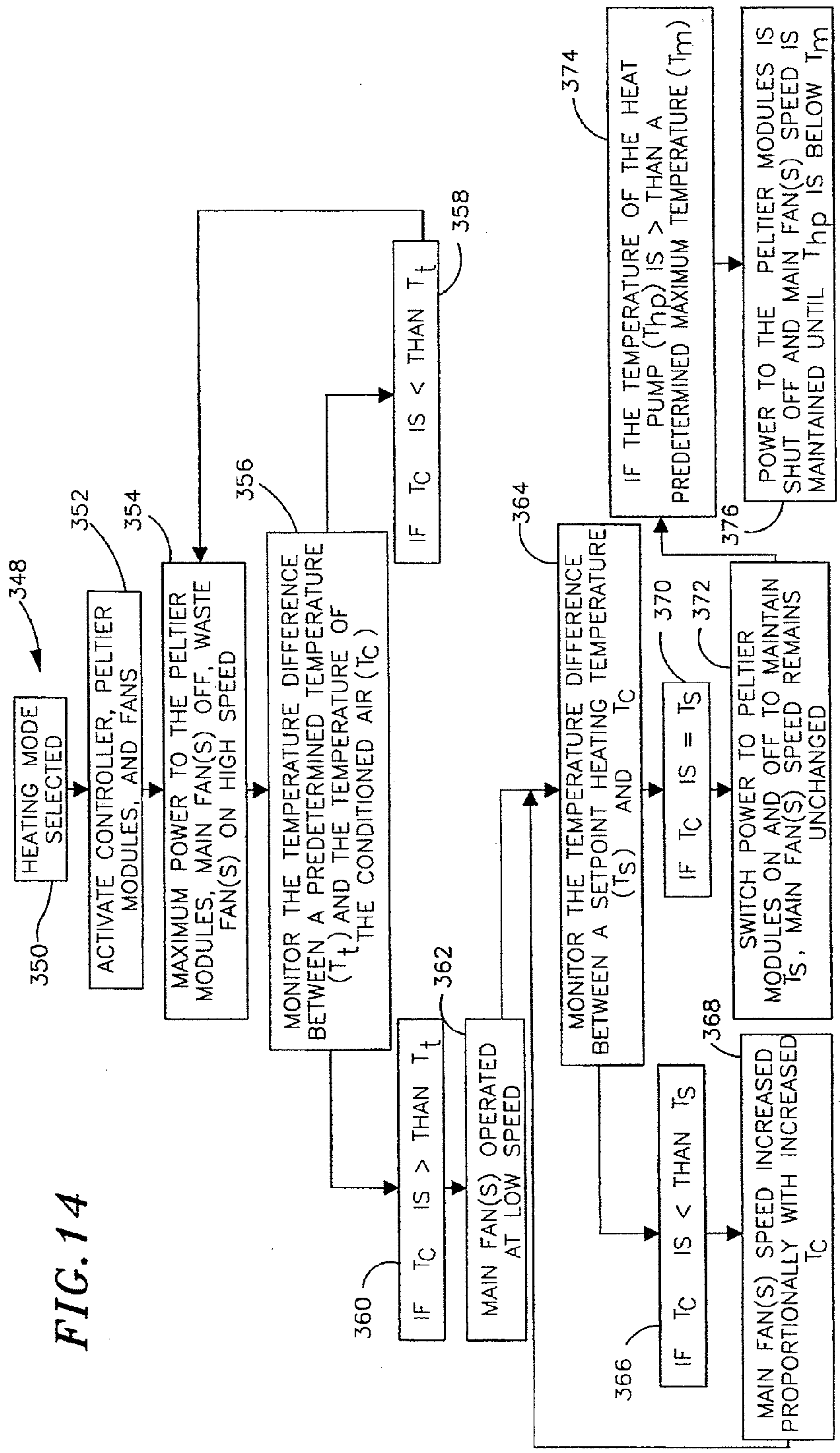

348
HEATING MODE SELECTED
350
ACTIVATE CONTROLLER, PELTIER MODULES, AND FANS
352
MAXIMUM POWER TO THE PELTIER MODULES, MAIN FAN(S) OFF, WASTE FAN(S) ON HIGH SPEED
354
MONITOR THE TEMPERATURE DIFFERENCE BETWEEN A PREDETERMINED TEMPERATURE (T_t) AND THE TEMPERATURE OF THE CONDITIONED AIR (T_C)
356
IF T_C IS < THAN T_t
358
IF T_C IS > THAN T_t
360
MAIN FAN(S) OPERATED AT LOW SPEED
362
MONITOR THE TEMPERATURE DIFFERENCE BETWEEN A SETPOINT HEATING TEMPERATURE (T_S) AND T_C
364
IF T_C IS < THAN T_S
366
MAIN FAN(S) SPEED INCREASED PROPORTIONALLY WITH INCREASED T_C
368
IF T_C IS = T_S
370
SWITCH POWER TO PELTIER MODULES ON AND OFF TO MAINTAIN T_S, MAIN FAN(S) SPEED REMAINS UNCHANGED
372
IF THE TEMPERATURE OF THE HEAT PUMP (Thp) IS > THAN A PREDETERMINED MAXIMUM TEMPERATURE (Tm)
374
POWER TO THE PELTIER MODULES IS SHUT OFF AND MAIN FAN(S) SPEED IS MAINTAINED UNTIL Thp IS BELOW Tm
376

FIG. 14

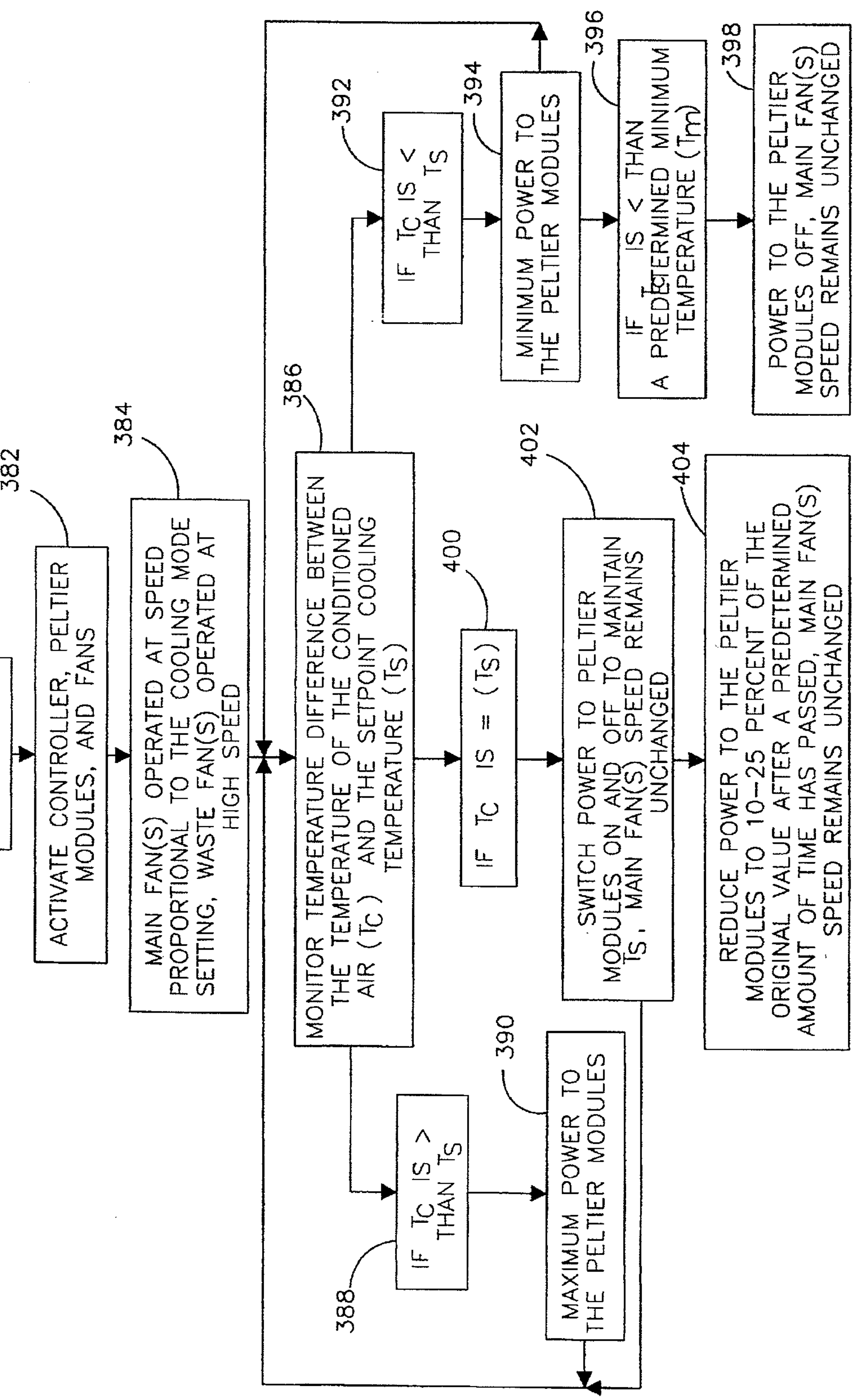

378
380
COOLING MODE SELECTED
382
ACTIVATE CONTROLLER, PELTIER MODULES, AND FANS
384
MAIN FAN(S) OPERATED AT SPEED PROPORTIONAL TO THE COOLING MODE SETTING, WASTE FAN(S) OPERATED AT HIGH SPEED
386
MONITOR TEMPERATURE DIFFERENCE BETWEEN THE TEMPERATURE OF THE CONDITIONED AIR (TC) AND THE SETPOINT COOLING TEMPERATURE (TS)
388
IF TC IS > THAN TS
390
MAXIMUM POWER TO THE PELTIER MODULES
400
IF TC IS = (TS)
402
SWITCH POWER TO PELTIER MODULES ON AND OFF TO MAINTAIN TS, MAIN FAN(S) SPEED REMAINS UNCHANGED
404
REDUCE POWER TO THE PELTIER MODULES TO 10–25 PERCENT OF THE ORIGINAL VALUE AFTER A PREDETERMINED AMOUNT OF TIME HAS PASSED, MAIN FAN(S) SPEED REMAINS UNCHANGED
392
IF TC IS < THAN TS
394
MINIMUM POWER TO THE PELTIER MODULES
396
IF TC IS < THAN A PREDETERMINED MINIMUM TEMPERATURE (Tm)
398
POWER TO THE PELTIER MODULES OFF, MAIN FAN(S) SPEED REMAINS UNCHANGED

FIG. 15

VARIABLE TEMPERATURE SEAT CLIMATE CONTROL SYSTEM

This invention was made with State of California support under a California Energy Commission Contract No. 50-94001. The Commission has certain rights to this invention.

REFERENCE TO PATENT APPLICATION

This application is a continuation-in-part of parent patent application Ser. No. 08/156,052, filed on Nov. 22, 1993, now U.S. Pat. No. 5,524,439.

FIELD OF THE INVENTION

The present invention relates generally to a variable temperature seat and, more specifically, to a method and apparatus for controlling the flow and temperature of a heating or cooling medium that heats or cools, directly or indirectly through the seat to an occupant positioned in such seat.

BACKGROUND OF THE INVENTION

Cooling or heating occupants of buildings, homes, automobiles and the like is generally carried out by convection through modifying the temperature of air surrounding the occupants environment. The effectiveness of convection heating or cooling is largely dependent on the ability of the temperature conditioned air to contact and surround all portions of the occupant's body. Heating and cooling occupants through convection is generally thought to be efficient in such applications as homes, offices, and other like structures where the occupants are not stationary or fixed in one position but, rather are moving around allowing maximum contact with the temperature treated air.

In other applications such as automobiles, planes, buses and the like, the occupants are typically fixed in one position with a large portion of their body's surface against the surface of a seat, isolated from effects of the temperature conditioned air. In such applications the use of distributing temperature conditioned air into the cabin of the vehicle to heat or cool the occupant is less effective due to the somewhat limited surface area of contact with the occupant's body. In addition, oftentimes the surface of the seat is at a temperature close to the ambient temperature upon initial contact by the occupant, increasing the need to provide rapid temperature compensation to the occupant in an effective manner.

To address the problem of providing effective occupant heating or cooling in such applications, seats have been constructed to accommodate the internal flow of a heating or cooling medium and to distribute the same through the seating surface to the surface of the occupant in contact with the seat. A preferred heating and cooling medium is air. A seat constructed in this manner increases the efficiency of heating or cooling a passenger by convection by distributing temperature conditioned air directly to the surface of the occupant that is generally isolated from contact with temperature conditioned air that is distributed throughout the cabin of the vehicle.

U.S. Pat. No. 4,923,248 issued to Feher discloses a seat pad and backrest comprising an internal plenum for distributing temperature conditioned air from a Peltier thermoelectric module through the surface of the seat pad and to an adjacent surface of an occupant. The temperature conditioned air is provided by using a fan to blow ambient air over

the fins of a Peltier module. The heating or cooling of the occupant is achieved by changing the polarity of the electricity that powers the Peltier module.

U.S. Pat. No. 5,002,336 issued to Feher discloses a joined seat and backrest construction comprising an internal plenum for receiving and distributing temperature conditioned air through the seat and to an adjacent surface of an occupant. Like U.S. Pat. No. 4,923,248, the temperature conditioned air is provided by a Peltier thermoelectric module and distributed through the internal plenum by an electric fan.

U.S. Pat. No. 5,117,638 issued to Feher discloses a selectively cooled or heated seat construction and apparatus for providing temperature conditioned air. The seat construction comprising, an internal plenum, a plastic mash layer, a metal mesh layer, and perforated outer layer. The apparatus for providing the temperature conditioned air is heat exchanger comprising a Peltier thermoelectric module and a fan. Heating or cooling the occupant is achieved by switching the polarity of the electricity powering the Peltier module.

The seat constructions known in the art, although addressing the need to provide a more efficient method of heating or cooling the occupant, has not addressed the need to provide temperature conditioned air to an occupant in a manner that both maximizes occupant comfort and maximizes power efficiency. Further, seat constructions known in the art have not addressed the possibility of directing temperature conditioned air to a second medium that is in contact with the occupant to effect conductive heat transfer.

The ever increasing awareness of our environment and the need to conserve resources has driven the need to replace hydrocarbon powered vehicles, such as the automobile, with vehicles that are powered by an environmentally friendly power sources such as electricity. The replacement of current hydrocarbon automobiles with electric powered vehicles will only become a reality if the electric powered vehicle can be operated and maintained in a manner equalling or bettering that of the hydrocarbon powered automobile it replaces. Accordingly, the need for electric vehicles to perform in an electrically efficient manner, is important to the success of the electric vehicle.

In order maximize the electrical efficiency of the electric powered vehicle it is necessary that the electrically powered ancillary components of the electric vehicle function at maximum electrical efficiency. The seats known in the art that provide temperature conditioned air to an occupant do not operate in an electrically efficient manner. The temperature of the air being conditioned by the Peltier thermoelectric devices in such seats is adjusted by dissipating the excess power through a resister, i.e., by using a potentiometer. The practice of dissipating excess power instead of providing only that amount of power necessary to operate the Peltier thermoelectric devices makes such seats unsuited for such power sensitive applications as the electric vehicle as well as other applications where electrical efficiency is a concern.

The seats known in the art constructed to provided temperature conditioned air to an occupant are adjustable in that the occupant may either choose to produce heated air or cooled air. However, the seats known in the art are unable to automatically regulate the temperature or flow rate of the cool or heated air being distributed to the occupant in the event that the thermoelectric device malfunctions or in the event that the user falls asleep. An electrical malfunctioning of the thermoelectric device could result in the abnormal

heating of the device, causing damage to the thermoelectric device itself. An electrical malfunction could result in the distribution of hot air to the occupant and result in discomfort. Additionally, an initial temperature setting of maximum heat or maximum cold that is left untouched in the event the occupant falls asleep may cause damage to the thermoelectric device itself or may cause discomfort or even injury to the occupant.

The seats known in the art, while able to vary the distribution of air to the seat bottom or seat back via occupant adjustment, do not allow the occupant to vary the temperature of the air passing to or through the seat back or seat bottom, independently. The option of being able to selectively heat one portion of the seat and cool the other may be desirable where the occupant requires such selective treatment due to a particular medical condition or injury. For example, one a cold day it would be desirable to distribute heated air to the seat back for occupant comfort and cooled air to the seat bottom to assist in healing a leg injury that has recently occurred.

Additionally, seats known in the art do not provide for conductive cooling through a non-perforated seating surface and rely entirely on convective heat transfer. Seats known in the art do provide for conductive heating through use of resistance wire placed within the seating surface. However, such seats cannot provide conductive cooling. Conductive heating and cooling is an effective method of transferring heat or cold from a seating surface to contacting portions of a seated occupant.

It is, therefore, desirable that a variable temperature seat comprise a control system and method for regulating the temperature and flow rate of temperature conditioned air to an occupant sitting in the seat. It is desirable that the control system operate the seat in an electrically efficient manner, making it ideal for use in power sensitive applications such as the electric powered vehicle. It is desirable that the control system operate the seat in a manner eliminating the possibility of equipment damage, occupant discomfort or injury. It is desirable that the control system permit the independent distribution of heated or cooled air to the seat back or seat bottom. It is desirable that a variable temperature seat comprise a control system capable of providing conductive as well as convective heat transfer to a seated occupant. It is also desirable that the control system be easy to operate with minimal occupant input.

SUMMARY OF THE INVENTION

There is, therefore, provided in practice of this invention a temperature climate control system for use with a variable temperature seat. The temperature climate control system comprises a variable temperature seat suitable for distributing temperature conditioned air to a seated occupant, at least one heat pump for temperature conditioning ambient air and passing the air to the seat, a temperature sensor, and a controller configured to monitor the temperature and regulate the operation of the heat pumps according to a temperature climate control logic.

Each heat pump comprises a number of Peltier thermoelectric modules for selectively heating or cooling ambient air in a main heat exchanger. The heated or cooled air is passed to the seat by a main exchanger fan. Each heat pump also comprises a waste heat exchanger for removing unwanted heat or cooling from the Peltier modules. The unwanted heat or cooling is passed to the outside environment by a waste exchanger fan.

Each main fan may be manually adjusted to operate at a variety of predetermined speeds via a fan switch. Each Peltier module can be manually adjusted to operate in various heating or cooling modes via a temperature switch. The electrical power to each Peltier is pulsed at a duty cycle corresponding to a particular heating or cooling mode of operation to optimize electrical efficiency. Each heat pump may be operated independently via separate fan and temperature switches, or may be operated simultaneously by a common fan and temperature switch. Alternatively, each heat pump may be operated automatically by the controller when the variable temperature seat is occupied by the activation of an occupant presence switch.

After an initial fan speed and Peltier temperature setting has been selected, the controller monitors the temperature information relayed from each heat pump. In addition, the controller may also be configured to monitor the ambient temperature of the air surrounding the variable temperature seat occupant as well as the temperature of the conditioned air directed to the variable temperature seat occupant, via the use of additional temperature sensors. The controller regulates the operation of each main exchanger fan, each waste exchanger fan, and each Peltier module according to a temperature climate control logic. The control logic is designed to maximize occupant comfort and minimize the possibility of equipment damage, occupant discomfort or even occupant injury in the event of a system malfunction.

The control logic is designed to interrupt or limit the power to the Peltier modules and/or each main exchanger fan in the event that the heat pump temperature exceeds a predetermined maximum temperature or a predetermined minimum temperature, indicating a possible heat pump malfunction. Additionally, the control logic is designed to adjust power to the Peltier modules in the event that the temperature of the conditioned air directed to the variable temperature seat occupant exceeds a predetermined maximum or minimum temperature.

The control logic is also designed to limit the power to the Peltier modules during the cooling mode of operation when the temperature of the cooling air directed to the occupant exceeds a predetermined minimum cooling temperature and the temperature has not been adjusted for a predetermined period of time, thus minimizing possible occupant discomfort associated with overcooling the occupant's back. In addition, the control logic is designed to limit the power to the Peltier modules during the cooling mode of operation when the temperature difference between the ambient air surrounding the variable temperature seat occupant and the conditioned air directed to the occupant is greater than a predetermined amount.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features and advantages of the present invention will become appreciated as the same becomes better understood with reference to the specification, claims and drawings wherein:

FIG. 1 is a cross-sectional semi-schematic view of an embodiment of a variable temperature seat;

FIG. 2 is a schematic view of a first embodiment of a temperature climate control system according to the present invention;

FIG. 3 is a flow chart illustrating a temperature climate control logic for the embodiment of the invention shown in FIG. 2;

FIG. 4 is a schematic view of a second embodiment of a temperature climate control system according to the present invention;

FIG. 5 is a flow chart illustrating a temperature climate control logic for the embodiment of the invention shown in FIG. 4;

FIG. 6 is a schematic view of a third embodiment of a temperature climate control system according to the present invention;

FIG. 7 is a flow chart illustrating a temperature climate control logic for the embodiment of the invention shown in FIG. 6;

FIG. 8 is a schematic view of an alternative embodiment of a temperature climate control system according to the present invention;

FIG. 9 is a cross-sectional semi-schematic view of a second embodiment of a variable temperature seat without convective heat transfer channels;

FIG. 10 is a cross-sectional semi-schematic view of a third embodiment of a variable temperature seat including air channels for effecting conductive heat transfer;

FIG. 11 is a schematic view of a fourth embodiment of a temperature climate control system according to the present invention;

FIG. 12 is flow chart illustrating a cooling mode logic for a first controlling method used with the fourth embodiment of the invention shown in FIG. 11;

FIG. 13 is flow chart illustrating a heating mode logic for the first controlling method used with the fourth embodiment of the invention shown in FIG. 11;

FIG. 14 is flow chart illustrating a heating mode logic for a second controlling method used with the fourth embodiment of the invention shown in FIG. 11; and

FIG. 15 is flow chart illustrating a cooling mode logic for a third controlling method used with the fourth embodiment of the invention shown in FIG. 11.

DETAILED DESCRIPTION

A temperature climate control system (TCCS) provided in the practice of this invention may be used to control the temperature of a heat transfer medium, preferably air, being distributed through a variable temperature seat (VTS) and directed to a seated occupant. The TCCS may be used in various VTS applications where it is required that an occupant stay seated for a period of time, such as automobiles, trains, planes, buses, dentists chairs, hair styling chairs and the like, or where an occupant simply desires an added degree of comfort while he/she is sitting at work or in the home, such as office chairs, home recliners and the like. The TCCS configured according to the practice of this invention to operate in a manner providing an occupant seated in a VTS a maximum degree of comfort by allowing the occupant to manually adjust both the flow rate and the temperature of the air being passed through the seat surface and directed to the occupant.

The TCCS is configured to automatically override the manual flow rate and temperature settings when it senses that the temperature of the air being directed to the occupant is above a predetermined maximum temperature set point or is below a predetermined minimum temperature set point. Thus, maximizing both occupant comfort and occupant safety in the event that the occupant either falls asleep or in the event that the device generating the temperature conditioned air malfunctions. The TCCS also comprises timers and is configured to automatically override the manual flow rate and temperature settings during normal operation to prevent back discomfort. Additionally, the device generating the temperature conditioned air is operated in a manner maximizing electrical efficiency, making it well suited for use in applications that are sensitive to electrical consumption, such as electric powered vehicles.

FIG. 1 shows an embodiment of a VTS 10 comprising a seat back 12 and a seat bottom 14 for accommodating the support of a human occupant in the sitting position. FIG. 1 shows a simplified cross-sectional view of a VTS for purposes of illustration and clarity. Accordingly, it is to be understood that the VTS may be constructed in embodiments other than that specifically represented. The VTS may be constructed having a outside surface covering 16 made from a suitable material that allows the flow of air through its surface, such as perforated vinyl, cloth, leather or the like. A padding layer 17 such as reticulated foam may lie beneath the outside surface 16 to increase occupant comfort.

The VTS may be constructed having a metal frame (not shown) that generally defines the seat configuration and having seat bottom and seat back cushions 18 made from foam and the like. A number of air channels 20 are positioned within each seat cushion and extend from the padding layer 17 through the seat cushions and to either a seat bottom air inlet 22 or a seat back air inlet 24. Although a particular embodiment of a VTS has specifically described, it is to be understood that the TCCS according to the present invention is meant to operate with any type of VTS having the same general features.

FIG. 2 shows a first embodiment of the TCCS according to the present invention comprising a VTS 10. The air that is passed through the seat and to the occupant is temperature conditioned by a heat pump. This first embodiment comprises a seat back heat pump 26 for temperature conditioning the air passed through the seat back 12 of the VTS, and a seat bottom heat pump 28 for temperature conditioning the air passed through the seat bottom 14 of the VTS. The seat back heat pump and seat bottom heat pump each comprise at least one thermoelectric device 30 and 32, respectively, for temperature conditioning, i.e., selectively heating or cooling, the air. A preferred thermoelectric device is a Peltier thermoelectric module. Each heat pump may comprise more than one Peltier thermoelectric module. A preferred heat pump comprises approximately three Peltier thermoelectric modules.

Each heat pump comprises a main heat exchanger 34 and 36, enclosing air temperature conditioning fins (not shown) depending from one surface of the Peltier modules, and a waste heat exchanger 39 and 40, enclosing thermal exchanger fins (not shown) extending from the Peltier module surface opposite the main heat exchanger. Attached to one end of each main heat exchanger is an outlet from a main exchanger fan 42 and 44 that serves to pass the temperature conditioned air in each main heat exchanger to the seat back or seat bottom, respectively. Each main exchanger fan may comprise an electrical fan having a suitable flow rate, such as an axial blower and the like. The outlet end of each main heat exchanger is connected to an air conduit 46 and 48 that is connected to the respective seat back air inlet 24 or seat bottom air inlet 22. Accordingly, the temperature conditioned air produced by the Peltier thermoelectric modules in each main heat exchanger is passed through the respective air conduit, through the respective air inlet, into and through the respective seat portion of the VTS to the occupant by the main exchanger fan.

Attached to one end of each waste heat exchanger is an outlet from a waste exchanger fan 50 and 52 that serves to pass unwanted waste heat or cooling produced in each waste heat exchanger to the outside environment surrounding the VTS. Each waste exchanger fan may comprise an electrical fan having a suitable flow rate, such as an axial blower and the like. The waste air exiting each waste heat exchanger fan is usually at an undesirable temperature, i.e., in the cooling

mode it is hot air and in the heating mode it is cold air. Consequentially, waste air exiting each waste exchanger may be specifically routed away from any occupant, possibly through the sides of the seat or the like.

Attached to the main exchanger side of the Peltier thermoelectric modules in each heat pump is a temperature sensor **54** and **56**. Each temperature sensor may comprise an electric thermocouple and the like.

The operation of the main exchanger fans **42** and **44** can be manually controlled by a fan switch **58**. In the first embodiment, it is preferred that the main exchanger fans are operated simultaneously by a single fan switch. The fan switch may comprise an electrical switch configured to provide an off position, and a variety of fan speed settings if desired. It is preferred that the fan switch be configured having an off position and three different fan speed settings, namely low, medium and high. The fan switch may be located within or near the VTS for easy occupant access.

The operation of the waste exchanger fans **50** and **52** can be manually controlled by a separate fan switch (not shown) if desired. However, it is preferred that the waste exchanger fans be activated automatically upon the operation of the main exchanger fans and operate at a single predetermined speed. Accordingly, upon the manual operation of the fan switch **58**, both the main exchanger fans are activated to a selected speed and the waste exchanger fans are automatically activated to operate at maximum speed. Configuring the TCCS to operate in this manner maximizes the thermal efficiency of the Peltier modules and reduces the possibility of system damage.

The operation of the Peltier thermoelectric modules can be controlled by a temperature switch **60**. In the first embodiment it is preferred that the Peltier thermoelectric modules in both heat pumps be operated simultaneously by a single temperature switch. The temperature switch may comprise an electrical switch configured to provide an off position, and a variety of temperature settings if desired. A preferred temperature switch is configured having an off position, four heating positions, and four cooling positions. Like the fan switch **58**, the temperature switch **60** may be located within or near the VTS for easy occupant access.

When the temperature switch is turned to one of the cooling positions a LED lamp **62** located near the temperature switch registers a green color, indicating that the Peltier modules are operating in the cooling mode. When the temperature switch is turned to one of the heating positions the LED lamp registers a red color, indicating that the Peltier modules are operating in the heating mode.

The different heating or cooling modes for the Peltier modules is accomplished by both switching the polarity and limiting the amount of the electrical power routed to the Peltier modules. To optimize the electrical efficiency of the Peltier modules, instead of using a potentiometer to discharge the unwanted portion of the electrical power through a resister, the four different modes of heating and cooling operation are achieved by pulsing electrical power to the Peltier modules at predetermined duty cycles. Accordingly, the different levels of heating or cooling are accomplished by pulsing the electrical power to the Peltier modules at a predetermined duty cycle. In a preferred embodiment, the duty cycle is about 0.02 seconds (50 hz) and the four different levels are accomplished by applying either 25 percent, 50 percent, 75 percent, or 100 percent of the cycle time power. In this embodiment, a 25 percent duty cycle would be on for approximately 0.005 seconds and off for approximately 0.015 seconds for a total cycle length of 0.02 seconds, and then repeated. The 75 percent duty cycle is on for approximately 0.015 seconds and off for approximately 0.005 seconds.

The heating or cooling mode of the Peltier modules is achieved by switching the polarity of the electrical power. The Peltier modules are configured to operate in the heating mode on approximately ten volts DC and in the cooling mode on approximately six volts DC. A DC converter may be positioned outside the controls to supply the heating and cooling voltage. The total duty cycle of the Peltier modules is adjustable from 0.02 to 0.2 seconds. The power for the Peltier modules in each mode was chosen to optimize the efficiency and total thermal power supplied to an occupant of the VTS.

The electrical feeds to and/or outlets from the fan switch **58**, temperature switch **60**, main exchanger fans **42** and **44**, waste exchanger fans **50** and **52**, Peltier thermoelectric modules **30** and **32** LED lamp **62**, and temperature sensors **54** and **56** are routed to a controller **64**. Alternatively, the electrical feeds and signals may first be routed to a printed circuit board in the seat (not shown) that sends a signal to the controller. The controller comprises a power inlet **66** of sufficient electrical capacity to operate all of the aforementioned devices. The controller is configured to receive occupant inputs from the fan switch and the temperature switch and temperature information from the temperature sensors. From this input the controller is configured to make adjustments to the operation of the heat pumps according to a predetermined logic designed to ensure occupant comfort and safety, and protect against system damage.

FIG. **3** is a flow chart illustrating a temperature climate control logic for the first embodiment of the TCCS shown in FIG. **2**. The occupant wishing to use the VTS operates the main exchanger fans by activating the fan switch **58** and selecting a desired fan speed (step **68**). Upon the activation of the main exchanger fans the waste exchanger fans are also activated to operate at a maximum speed (step **70**).

The occupant may activate the Peltier modules for temperature conditioning the air in the VTS by positioning the temperature switch **60** to a desired heating or cooling mode (steps **72** and **74**). The Peltier modules can be manually deactivated by selecting the "off" position on the temperature control switch, in which case the power to the fans is maintained as indicated by the LED **62** registering a green color (step **76**). Additionally, the Peltier modules are automatically deactivated by the controller when the fan switch is manually placed in the "off" position (step **78**).

When the temperature switch is positioned to one of the four cooling modes the LED lamp **62** registers a green color (step **80**). The temperature detected by the temperature sensors **54** and **56** in both heat pumps **26** and **28** is passed to the controller (step **82**). If the temperature is below about 303° K. (step **84**) the power to the Peltier modules remains on (step **86**), unless more than six minutes has elapsed since the time that the occupant has last adjusted the temperature (step **88**), in which case the power to the Peltier modules is reduced to 25 percent (step **90**). It is desirable to reduce the power to the Peltier modules under such circumstances to prevent over cooling of the occupant's back, which has been shown to cause the occupant discomfort after use of the VTS. If the temperature is not below 303° K., however, the power to the Peltier modules is maintained as indicated by the occupant controls (step **86**).

When the temperature switch is positioned to one of the four heating modes the LED lamp **62** registers a red color (step **92**). If the temperature is below about 339° K. (step **94**)

the power to the Peltier modules remains on (step **96**). If the temperature is in the range of from 339° K. to 349° K. (step **92**) the power to the Peltier modules is reduced to 25 percent until the temperature is below 339° K. (step **98**). Reducing the power to the Peltier modules in this situation is desired to prevent the Peltier modules from overheating.

If the temperature of the main heat exchanger side of the Peltier modules is below either below 200° K. or above 349° K. (step **100**), regardless of whether the Peltier modules are in the heating or cooling mode, the controller deactivates the Peltier modules (step **76**) and maintains the operation of the main exchanger fans and waste exchanger fans. The occurrence of either of the above temperature conditions indicates a system malfunction. In this condition the LED lamp **62** registers a orange color, indicating a system malfunction.

The first embodiment comprises conditioned air temperature sensors **102** and **104** positioned in the air flow of the temperature conditioned air passing to the seat, back and seat bottom, respectively, as shown in FIG. **2**. The conditioned air temperature sensors are electrically connected to the controller **64**. The temperature climate control logic described above and illustrated in FIG. **3** is configured to deactivate the Peltier modules in the event that the temperature of the conditioned air is greater than about 325° K. or below about 297° K.. While the Peltier modules are deactivated the main exchanger fans continue to run.

FIG. **4** shows a second embodiment of the TCCS according to the practice of the present invention. The second embodiment is similar to the first embodiment in all respects, except for the addition of at least one ambient air temperature sensor **102** to monitor the temperature of the air outside of the VTS surrounding the occupant. The temperature sensor is electrically connected to relay ambient air temperature information to the controller **64**. More than one ambient air temperature sensor may be used, each being positioned at different locations in the environment surrounding the occupant, to provide an ambient air temperature profile to the controller.

The second embodiment of the TCCS also differs from the first preferred embodiment in that the fan speed and air temperature for the seat back heat pump **26** and the seat bottom heat pump **28** can each be manually adjusted independently by using a separate seat back fan switch **104** and seat bottom fan switch **106**, and a separate seat back temperature switch **108** and seat bottom temperature switch **110**. The fan switches **104** and **106** and the temperature switches **108** and **110** in the second embodiment are the same as those previously described in the first embodiment. Alternatively, the TCCS may be configured having a single fan switch (not shown) to control the speed of fans **42** and **44** and two temperature switches (not shown) to control the power to each heap pump **26** and **28** independently. The TCCS may also be configured having a single temperature switch (not shown) to control the power of heat pumps **26** and **28** simultaneously and two fan switches to control the speed of each fan **42** and **44** independently.

LED lamps **112** and **114** are located near each temperature switch to indicate the mode of operation selected for each heat pump, e.g., in the off position the LED lamps are off, when both heat pumps are in the cooling mode the LED lamps register a green color, when both heat pumps are in the heating mode the LED lamps register a red color, when there is a temperature error or Peltier module malfunction in either heat pump the LED lamps fast cycle red and green, registering an orange color.

Configuring the manual fan speed and temperature switches in this manner allows the occupant the ability to

operate the seat back **12** of the VTS at a different conditions than the seat bottom **14**. This may be desirable where a medical condition or injury requires that a particular portion of the occupant's body be maintained at a temperature different from the remaining portion of the occupant, e.g., where a leg injury requires cooling air in the seat bottom of the VTS and the ambient temperature dictates that heated air pass through the seat back for maximum occupant comfort.

Like the first embodiment, the electrical feeds to and/or outlets from the fan switches **104** and **106**, temperature switches **108** and **110**, main exchanger fans **42** and **44**, waste exchanger fans **50** and **52**, Peltier thermoelectric modules **30** and **32**, temperature sensors **54** and **56**, LED lamps **112** and **114**, and the ambient air temperature sensor **102** are routed to the controller **64**.

FIG. **5** is a flow chart illustrating a temperature climate control logic for the second embodiment of the TCCS shown in FIG. **4**. The control logic is similar to that previously described above and shown in FIG. **3**, except for the additional temperature inputs from the ambient temperature sensor (step **116**) and the conditioned air sensor, and except when the Peltier modules are being operated in the cooling mode and the temperature of the conditioned air from the seat back heat pump **26** is below about 310° K. (step **119**). When the conditioned air temperature is below about 310° K., if it has been greater than six minutes since the last temperature adjustment by the occupant (step **120**), and the conditioned air temperature of the conditioned is approximately 3° K. or more below the temperature of the ambient air surrounding the occupant (step **122**), the controller reduces the power to the Peltier modules in the seat back heat pump **26** to approximately 25 percent (step **124**). If the temperature is below about 310° K., but it has either been less than six minutes since the last manual temperature adjustment or the conditioned air temperature is less than 3° K. below the ambient temperature, the power to the Peltier modules in the seat back heat pump remains on at the occupant controlled setting (step **126**).

Like the control logic described in FIG. **3**, the reason for reducing the power to the Peltier modules under such conditions is to regulate the amount of cooling air directed to an occupant's back to prevent possible discomfort after using the VTS.

The second embodiment also comprises conditioned air temperature sensors **128** and **130** positioned in the air flow of the temperature conditioned air passing to the seat, back and bottom, respectively, as shown in FIG. **4**. The conditioned air temperature sensors are electrically connected to the controller **64**. The temperature climate control logic described above and illustrated in FIG. **5** is configured to deactivate the Peltier modules in the event that the temperature of the conditioned air directed to the occupant is greater than about 325° K. or below about 297° K.. While the Peltier modules are deactivated the main exchanger fans continue to run.

FIG. **6** shows a third embodiment of the TCCS according to the practice of this invention. The third embodiment is similar to the first embodiment in all respects except for two. One is the addition of at least one ambient air temperature sensor **132** to monitor the temperature of the air outside of the VTS surrounding the occupant. The temperature sensor is electrically connected to feed temperature information to the controller **64**. More than one ambient air temperature sensor may be used, each being positioned at different locations in the environment surrounding the occupant, to provide an ambient air temperature profile to the controller.

The second difference in the third embodiment of the TCCS is that only a single heat pump **134** is used to provide temperature conditioned air to both the seat back **12** and the seat bottom **14**. The single heat pump is similar to the seat back heat pump **26** and seat bottom heat pump **28** previously described in the first embodiment in that it comprises a main heat exchanger **136**, a main exchanger fan **138**, a waste heat exchanger **140**, a waste exchanger fan **142** and a Peltier module temperature sensor **143**. However, instead of three Peltier thermoelectric modules, the single heat pump **134** comprises four Peltier thermoelectric modules **144**. The temperature conditioned air from the main heat exchanger is passed to the seat back **12** and seat bottom **14** of the VTS by an air manifold **146** connected at one end to the outlet of the main heat exchanger **136** and at the other end to the seat back air inlet **24** and seat bottom air inlet **22**. Alternatively, the third embodiment of the TCCS may comprise a double heat pump arrangement similar to that previously described in the first embodiment.

The third embodiment of the TCCS also differs from the first embodiment in that the main exchanger fan speed and the heat pump air temperature are not manually adjustable by the occupant. Rather, the fan speed and the air temperature are controlled automatically by the controller **64**. Additionally, an occupant presence switch **148** is located within the VTS that is activated upon the presence of an occupant in the seat. The occupant presence switch may comprise a weight sensitive switch and the like located in the seat back or seat bottom. In a preferred embodiment, the occupant presence switch is located in the seat bottom and is electrically connected to the controller to relay the presence of an occupant. The use of a occupant presence switch to control the activation of the VTS is desired for purposes of conserving electricity when the VTS is not occupied and when it is not practical or desirable to give individual control over the seats. e.g., in bus passenger seating applications.

FIG. **7** is a flow chart illustrating a temperature climate control logic for the third embodiment of the TCCS as shown in FIG. **6**. The activation of the main exchanger fan **138** is controlled by an occupant sitting in the VTS (step **150**), which activates the occupant presence switch, and the ambient conditions inside the vehicle as transmitted to the controller by the ambient temperature sensors (step **148**). To ensure a rapid temperature response upon placement of an occupant in the VTS, the controller pulses electrical power to the Peltier modules in the absence of an occupant at a steady state of voltage in the range of from 0.5 to 1 volt (step **152**). The voltage that is actually applied during the duty cycle may be six or twelve volts. By maintaining a slow continuous pulse of power to the Peltier modules the transient time for achieving the desired temperature of conditioned air upon the presence of an occupant in the VTS is greatly minimized.

Once an occupant is seated in the VTS, the particular main fan speed and Peltier operating mode selected by the controller is dependent upon the ambient temperature surrounding the VTS occupant. When the ambient temperature is less than about 286° K. (step **154**) the controller selects a heating mode of operation and passes 100 percent power to the Peltier modules and operates the main exchanger fan at medium speed (step **156**). Upon the activation of the main exchanger fan the waste exchanger fan is also activated at high speed.

When the ambient temperature is between 286° K. and 290° K. (step **158**) the controller selects a heating mode of operation and passes 75 percent power to the Peltier modules and operates the main exchanger fan at medium speed

(step **160**). When the temperature is between 290° K. and 293° K. (step **162**) the controller selects a heating mode of operation and passes 25 percent power to the Peltier modules and operates the main exchanger fan at medium speed (step **164**).

When the ambient temperature is between 293° K. and 297° K. the (step **166**) the controller pulses power to the Peltier modules at a steady state of approximately 0.5 volts and deactivates the main exchanger fan (step **168**).

When the ambient temperature is between 297° K. and 300° K. (step **170**) the controller selects a cooling mode of operation and passes 50 percent power to the Peltier modules and operates the main exchanger fan at medium speed (step **172**). When the ambient temperature is between 300° K. and 302° K. (step **174**) the controller selects a cooling mode of operation and passes 50 percent power to the Peltier modules and operates the main exchanger fan at high speed (step **176**). When the ambient temperature is above 302° K. (step **178**) the controller selects a cooling mode of operation and passes 100 percent power to the Peltier modules and operates the main exchanger fan at high speed (step **180**).

In either the heating mode of operation (ambient temperatures up to 293° K.) or the cooling mode of operation (ambient temperatures above 297° K.), a Peltier module temperature (step **182**) below 200° K. or above 349° K. (step **184**) causes the controller to deactivate the Peltier modules and maintain the operation of the main exchanger fan and waste exchanger fan (Step **186**). Either of the above conditions indicate a system malfunction.

The third embodiment also includes a conditioned air temperature sensor **188** positioned in the air flow of the temperature conditioned air passing to the seat, as shown in FIG. **6**. The conditioned air temperature sensor is electrically connected to the controller **64**. The temperature climate control logic described above and illustrated in FIG. **7** is configured to deactivate the Peltier modules **144** in the event that the temperature of the conditioned air passing to the seat and to the occupant is greater than about 325° K. or below about 297° K. While the Peltier modules are deactivated the main exchanger fans continue to run.

The third embodiment of the TCCS as specifically described above and illustrated in FIG. **6** is used for controlling multiple VTSs in multi-occupant applications such as buses, trains, planes and the like. In such an application the main exchanger fan, waste exchanger fan, Peltier modules, temperature sensor, and weight sensitive switch from each VTS are electrically connected to a common controller. Multiple ambient air temperature sensors may be placed at different locations within the vehicle to provide an accurate temperature profile throughout the interior of the vehicle. The common controller is configured to accommodate inputs from the multiple ambient air temperature sensors. The common controller may be configured to control the main fan speed and mode of operation for the Peltier modules in the same manner as that specifically described above and illustrated in FIG. **7**, taking into account the possibility of different ambient temperature zones within the vehicle surrounding each VTS.

Although limited embodiments of the temperature climate control system have been described and illustrated herein, many modifications and variations will be apparent to those skilled in the art. For example, it is to be understood within the scope of this invention that a temperature climate control system according to the present invention may comprise means for automatically adjusting the flow of temperature conditioned air from a single heat pump to the seat back or the seat bottom.

FIG. 8 illustrates an alternative embodiment of the third embodiment of the TCCS, incorporating the use of valves **190** and **192** placed in the air manifold **146** leading to the seat back and the seat bottom, respectively. The valves are activated electrically by a controller **64** according to a predetermined control logic. The control logic may be the same as that specifically described above and illustrated in FIG. **7** for the third embodiment, with the addition that controller limits the flow of cooling air to the seat back by closing valve **190** in the event that the occupant receives too much cooling air over a period of time. This embodiment would help eliminate the occurrence of occupant discomfort after using the VTS.

FIG. **9** illustrates a second embodiment of a VTS **194** including a seat back **196** and seat bottom **198** for accommodating the support of a human occupant in a seated portion. The VTS **194** includes an outside surface covering **200** that is made from a suitable material that allows the flow of air through its surface, such as cloth, perforated vinyl, perforated leather and the like. A padding layer **202**, such as reticulated foam, is disposed beneath the outside surface covering **200** to increase occupant comfort. Unlike the first embodiment of the VTS **10** shown in FIG. **2**, the VTS **194** does not include air channels that extend through the seat bottom and seat back cushions **18**. Rather, the VTS **194** includes seat bottom and seat back cushions **204** that extend from the padding layer **202** to an air inlet distributor **206** disposed along a backside surface of the seat back and seat bottom.

The seat bottom and seat back cushions **204** can be made from a porous material such as foam and the like that is capable of accommodating air flow therethrough, so that conditioned air introduced into each air distributor **206** is passed through the seat back and seat bottom cushions, through the padding layer **202**, through the surface covering **200** and onto the adjacent surface of a seated occupant. Accordingly, rather than passing conditioned air through the cushions via air channels disposed within the cushions, the conditioned air is passed through the cushion material itself. This avoids the need to manufacture seat back and seat bottom cushions having a number air channels therethrough and, therefore, reduces the cost and time associated with manufacturing the VTS.

FIG. **10** illustrates a third embodiment of a VTS **208** including a seat back **210** and seat bottom **212** for accommodating the support of a human occupant in a seated portion. The VTS **208** includes an outside surface covering **214** that is made from a non-perforated material, such as vinyl, leather and the like. Unlike the first and second embodiments of the VTS, the third embodiment of the VTS **208** relies on conductive heat transfer, rather than convective heat transfer, to providing heating and cooling to a seated occupant.

The VTS may include a padding layer **216** disposed beneath the outside surface covering **214** to provide added comfort to a seated occupant and improve air distribution beneath the seat cover. Seat back and seat bottom cushions **218** extend from the padding layer **216** to a backside surface of each seat bottom and seat back. At least one air channel **220** is interposed between the padding layer **216** and the seat back and seat bottom cushions, and extends along a length of the seat bottom and seat back. The air channel **220** disposed within the seat bottom **212** comprises an air inlet channel **222** at one end of the seat bottom that extends through the seat cushion **218** to an inlet opening **224** at the backside of the seat bottom, and an air outlet channel **226** at an opposite end of the seat bottom that extends through the seat cushion **218** to an outlet opening **228** at the backside of the seat bottom. The air channel **220** disposed within the seat back **210** comprises an air inlet channel **230** at one end of the seat back that extends through the seat cushion **218** to an inlet opening **232** at the backside of the seat back, and an air outlet channel **234** at an opposite end of the seat back that extends through the seat cushion **218** to an outlet opening **236** at the backside of the seat back.

The VTS **208** provides heating and cooling to a seated occupant via conductive heat transfer by recirculating temperature conditioned air against a backside surface of the padding layer **216**. Alternatively, the VTS **208** may be constructed without the padding layer, with a padding layer of minimal thickness, or with a porus padding layer so that conditioned air recirculated through the air channels **220** is in direct contact with a backside surface of the surface covering **214** to better facilitate conductive heat transfer to the occupant seated on the front side surface of the surface covering. As will be discussed in greater detail below, temperature conditioned air enters the seat bottom and seat back via respective air inlet openings **224** and **232**, and is circulated across and/or through the padding layer **216** as it is passed through the respective air channels **220**. The conditioned air exits the seat bottom and seat back via the respective outlet openings **228** and **236**, is again conditioned within a heat pump, and is directed again into each seat bottom and seat back.

Although particular embodiments of the VTS have been described and illustrated, it is understood that other embodiments of the VTS may be constructed that are within the scope of this invention. For example, an alternative embodiment of a VTS may include a hybrid configuration that provides heating and cooling to a seated occupant via both convective and conductive heat transfer. In such embodiment, the VTS can be constructed having a number of air channels disposed therein to direct temperature conditioned air through a perforated portion of an outside surface covering to an adjacent surface of the seated occupant (such as that shown in FIGS. **1** and **10**) to provide convective heating and cooling. In such embodiment, the VTS may also comprise a number of air channels disposed along a backside surface of a non-perforated portion of the outside surface covering to accommodate recirculation of temperature conditioned air to provide conductive heat transfer to an adjacent surface of the seated occupant (such as that shown in FIG. **10**). For example, the VTS can be configured with an outside surface covering having a non-perforated portion to facilitate conductive heat transfer positioned at the center of each seat bottom and seat back, defining the primary seating surface, and a perforated portion to facilitate convective heat transfer posited at each side of the central portion, defining a peripheral portion of the seating surface.

Additionally, the VTS may be configured to facilitate conductive heat transfer to and from a seated occupant using a heat transfer medium other than air, such as water and the like. Accordingly, in such an embodiment, the liquid heat transfer medium would be circulated through the seat and be in contact with a backside portion of a seating surface.

Additionally, an alternative embodiment of the VTS can be configured with valves and the like to effect convective heat transfer during initial operation of the VTS and switch to conductive heat transfer after a predetermined state of operation has been achieved, by first directing temperature conditioned air to the perforated portion of the seat, e.g., the side edges of the seating surface, and then switching the routing of the temperature conditioned air to the non-perforated portion, e.g., the central portion of the seating surface.

FIG. 11 illustrates a fourth embodiment of the TCCS **238** comprising a third embodiment of the VTS **240** as described above and illustrated in FIG. **10**. The TCCS is configured to accommodate recirculation of temperature conditioned heat transfer medium, preferably air, through the seat bottom **242** and seat back **244** to provide conductive heating and cooling to a seated occupant. The TCCS comprises at least one heat pump **246** of the type previously described for the first, second, and third embodiments of the TCCS and illustrated in FIGS. **2**, **4** and **6**, including at least one Peltier thermoelectric module **248**, a main heat exchanger **250**, a waste heat exchanger **252**, and at least one fan. Accordingly, the main heat exchanger and waste heat exchanger may be configured to share a common fan. In a preferred embodiment, the heat pump comprises at least one main exchanger fan **254**, and a waste exchanger fan **256**.

The main exchanger fan **254** has an outlet connected to one end of the main exchanger **250** and serves to pass air that has been temperature conditioned by the Peltier modules within the main exchanger to an inlet air manifold **258**. The inlet air manifold is connected to air inlet openings **260** and **262** in the seat bottom **242** and seat back **244**, respectively, by air inlet tubing **264**. Temperature conditioned air is passed through the air inlet manifold **258** in parallel flow through the air inlet tubing, through the air inlet openings, and into the seat bottom and seat back of the VTS.

Temperature conditioned air is routed through each seat bottom and seat back via at least one air inlet channel **266** disposed through a seat cushion **268** at one end of the cushion, at least one air channel **270** interposed between an outside surface cover **272** and the seat cushion **268** and extending along a length of the seat bottom and seat back, and at least one air outlet channel **274** disposed through the seat cushion at an opposite end of the cushion. The temperature conditioned air passed through the air channels **270** is in contact with a backside surface of the cover **272**, effecting conductive heat transfer through its thickness, and to a front side surface of the cover and to an adjacent surface of a seated occupant.

The temperature conditioned air exits the seat bottom and seat back via air outlet openings **276** and **278**, respectively, after it has effected conductive heat transfer to the outside surface cover **272**. Each air outlet opening is connected by air outlet tubing **280** to an inlet end or intake **282** of the main exchanger fan **254**. The temperature conditioned air that exits the seat bottom and seat back is directed in parallel flow to the intake **282** of the main fan **254** where it is passed by the fan into the main exchanger **250** and reconditioned before again being introduced into the VTS. Accordingly, the TCCS **238** is configured to accommodate the recirculation of temperature conditioned air through the VTS to accommodate heating and cooling via conductive heat transfer.

The TCCS **238** comprises a control switch **284** for operation by a seat occupant to simultaneously activate operation of the Peltier thermoelectric modules **248**, main exchanger fan **254**, and waste exchanger fan **256** according to cooling and heating control logic described in detail below. The control switch **284** an analog switch that is capable being switched to an off position, or to provide a continuously variable temperature adjustment. For example, the control switch may be configured to provide a continuum of different cooling temperatures between approximately 65° F. and 75° F., and a continuum of different heating temperatures between approximately 76° F. and 85° F.

At least one temperature sensor **286**, in the form of a thermocouple and the like, is attached to the main exchanger **250** of the heat pump **246** to provide an indication of the operating temperature of the Peltier modules **248**. At least one temperature sensor **288**, in the form of a thermocouple and the like, is also located within the inlet air manifold **258** to provide an indication of the temperature of the air exiting the main exchanger **250**. The temperature sensors **288** may be mounted at other locations within the temperature conditioned air recirculation conduits as to provide further temperature information if desired.

Electrical leads to the Peltier modules **248**, main exchanger fan **254**, waste exchanger fan **256** extend from a controller **290**. The controller comprises a power inlet **292** of sufficient electrical capacity to operate all of the aforementioned devices. The controller is configured to receive occupant input via the control switch **284**, and to receive temperature information from the main exchanger temperature sensor **286** and conditioned air temperature sensor **288**. From these inputs the controller is configured to make adjustments to the operation of the heat pump **246** and main exchange fan or fans **254** according to a predetermined cooling and heating control logic designed to ensure occupant comfort and safety, and protect against system damage.

The controller **290** is configured to route DC voltage in the range of from 0 to 12 volts to the Peltier modules **284**. In the cooling mode, the controller can route up to about 6 volts DC to the Peltier modules depending on the particular set point cooling temperature and the temperature of the conditioned air. In the heating mode, the controller can route up to about 12 volts DC to the Peltier modules depending on the particular set point heating temperature and the temperature of the conditioned air. The controller **290** is configured to provide DC output to the Peltier modules at varied voltages, depending on the particular heating or cooling condition, rather than providing a fixed voltage that is pulsed over time.

The controller **290** is configured to monitor the current draw of the Peltier modules **284** and to limit the power consumption of the Peltier modules if the current draw exceeds a predetermined value as required by the power source. The controller monitors the current draw and regulates power consumption so that the Peltier modules are operated at a maximum allowed current at all conditions. In this manner, the controller ensures that the maximum allowable current, as required by the power source, is not exceeded by the operation of the Peltier modules. The need to regulate the power consumption of the Peltier modules is especially important when the TCCS is used in applications powered by an electrical source, such as an electric powered automobile. In such an application, regulating the power consumption of accessory features has a direct impact on the range and driving performance of the vehicle.

While the fourth embodiment of the TCCS **238** has been described and illustrated with the third embodiment of the VTS **208**, it is to be understood within the scope of this invention that other embodiments of the VTS can also be used in conjunction with the TCCS **238**. For example, the TCCS **238** can be used to provide temperature conditioned air to the first and second embodiments of the VTS, **10** and **194**, respectively, that are configured to accommodate convective heat transfer to a seated occupant. To accommodate use of these VTS embodiments with the TCCS **238** it may be necessary to modify the TCCS **238** by removing the air outlet tubing **280** from the intake **282** of the main fan **254** so that the heat pump does generate recirculating flow through the VTS. Rather the TCCS **238** configured in this manner provide temperature conditioned air to the VTS that is then passed through the VTS and to the seated occupant at the desired set point heating or cooling temperature.

FIG. **12** is a flow chart illustrating a cooling mode control logic **294** for a first controlling method used to operate the TCCS **238** in a cooling mode of operation. An occupant wishing to use the VTS **240** operates the control switch **284** to provide a desired cooling temperature, i.e., sets the control to a cooling mode of operation (step **296**). Alteratively, the cooling mode of operation can be selected automatically by, for example, thermostatic control based on a predetermined difference in temperature inside and outside of the vehicle. This activates the controller **290**, Peltier modules **248**, the main exchanger fan(s) **254** and waste exchanger fan(s) **256** (step **298**). The waste fan(s) is operated at high speed (step **300**).

The main fan(s) is operated at a speed proportional to the cooling mode setting. For example, if the cooling mode setting is low, i.e., a relatively high cooling temperature, the main fan(s) is operated at a low speed. If the cooling mode setting is high, i.e., a relatively low cooling temperature, the main fan(s) is operated at a high speed. And if the cooling mode setting is medium, i.e., a moderate cooling temperature, the main fan(s) is operated at a medium speed.

The Peltier modules are operated by receiving a level of power proportional to the cooling mode setting (step **304**). For example, if the cooling mode setting is low, i.e., a relatively high cooling temperature, the Peltier modules receive a minimum level of power. If the cooling mode setting is high, i.e., a relatively low cooling temperature, the Peltier modules receive a maximum level of power. And if the cooling mode setting is medium, i.e., a moderate cooling temperature, the Peltier modules receive a moderate level of power. Accordingly, the cooling mode logic for the first controlling method regulates the operation of both the main fan(s) and the Peltier modules based on the particular cooling mode setting. The only input required by the seat occupant is the selection of a desired cooling temperature.

The cooling mode logic **294** monitors whether the Peltier modules have been operated for a predetermined length of time (step **306**). In a preferred embodiment, the predetermined length of time is in the range of from 5 to 15 minutes. If the Peltier modules have not been operated for the predetermined length of time, power to the Peltier modules is maintained according to step **306**. If the Peltier modules have been operated for the predetermined amount of time, the power to the Peltier modules is reduced to approximately 10 to 25 percent of the original power level (step **308**). It is desired to decrease the amount of cooling provided to the VTS **240** after a predetermined amount of time to prevent overcooling a seated occupant's back, which has been shown to cause occupant discomfort.

If the occupant subsequently adjusts the control switch **284**, or the control switch is automatically adjusted, to a new T_s (step **310**) after the power to the Peltier modules has been reduced (step **306**), the cooling mode logic **294** continues to regulate the speed of the main fan(s) in a manner proportional to the new cooling mode setting (step **302**), and regulate the level of power directed to the Peltier modules in a manner proportional to the new cooling setting, but within the 10 to 25 percent reduced power of step **308** (step **312**).

FIG. **13** is a flow chart illustrating a heating mode control logic **314** for a first controlling method used to operate the TCCS **238** in a heating mode of operation. An occupant wishing to use the VTS **240** operates the control switch **284** to provide a desired heating temperature, i.e., sets the control to a heating mode of operation (step **316**). Alteratively, as mentioned above, the heating mode of operation can be selected automatically by, for example, thermostatic control based on a predetermined difference in temperature inside and outside of the vehicle. This activates the controller **290**, Peltier modules **248**, the main exchanger fan(s) **254** and waste exchanger fan(s) **256** (step **318**).

The heating mode logic provides power to the Peltier modules at a level proportional to the heating mode setting (step **320**). For example, if a low heating mode setting is selected, i.e., a relatively low heating temperature, a minimum level of power is directed to the Peltier modules. If a high heating mode setting is selected, i.e., a relatively high heating temperature, a maximum level of power is directed to the Peltier modules. The heating mode control logic also keeps the main fan(s) off and operates the waste fan(s) at high speed (step **320**).

The heating mode control logic **294** monitors the temperature difference between a predetermined threshold temperature (T_t) and the temperature of the conditioned air (T_c) (step **322**), as provided by the temperature sensor **288**. If T_c is less than T_t (step **324**), i.e., the temperature of the conditioned air is cooler than the threshold temperature, the power to the Peltier modules is maintained at its original setting and the main fan(s) is off (step **320**). If T_c is greater than T_t (step **340**), the main fan(s) is operated at low speed (**328**). In a preferred embodiment, the predetermined threshold temperature is approximately 100° F. It is to be understood that the threshold temperature is arbitrary and is largely a function of the particular application of the TCCS and the particular embodiment of the VTS. It is desirable to maintain power to the Peltier modules while keeping the main fan(s) off until the T_t is reached to achieve a rapid temperature rise within the main heat exchanger **250** and, thereby provide a rapid response time, i.e., reduce the time needed for the T_c to reach a predetermined setpoint heating temperature.

Once the T_c is greater than the T_t and the main fan(s) is operated, the heating mode control logic **314** monitors the difference in temperature between a setpoint heating temperature (T_s) and the T_c. If the T_c is less than the T_s (step **332**), i.e., the temperature of the conditioned air is below the heating mode setpoint temperature, the speed of the main fan(s) proportional with the T_c (step **334**). For example, as the T_c increases so does the speed of the main fan(s). Increasing the main fan(s) speed with rising T_c until the T_s is reached promotes a rapid response time as well as a greater heating effect discussed above. If the T_c is equal to the T_s (step **336**), the operation of the main fan(s) is maintained at the existing speed setting (step **338**). If the T_c is greater than the T_s (step **340**), the speed of the main fan(s) is increased proportionally with increased T_c (step **342**). For example, as the T_c increases so does the speed of the main fan(s). Increasing the speed of the main fan(s) with increasing T_c helps to remove the excess heat that is generated by the heat pump, thereby regulating the temperature of the conditioned air back to the T_s.

The heating mode logic **314** monitors the temperature of the heat pump (T_{hp}) **246**, by use of the temperature sensor **286**, and determines whether the T_{hp} exceeds a predetermined maximum temperature (T_m) (step **344**). If the T_{hp} is greater than the T_m, the power to the Peltier modules is shut off and the main fan(s) speed is maintained until the T_{hp} falls below the T_m (**346**). In a preferred embodiment the predetermined maximum temperature is approximately 100° F. A heat pump temperature above the predetermined maximum temperature indicates that a malfunction in the heat pump has occurred. Shutting off power to the Peltier modules ensures that a seated occupant will not be harmed or suffer discomfort as a result of such malfunction.

A second controlling method for use with the TCCS **238** described and illustrated above includes a cooling mode control logic that is identical to the cooling mode control logic **294** described above and illustrated in FIG. **12** for the first controlling method. FIG. **14** is a flow chart illustrating a heating mode control logic **348** of the second controlling method used to operate the TCCS **238** in a heating mode of operation. An occupant wishing to use the VTS **240** operates the control switch **284** to provide a desired heating temperature, i.e., sets the control to a heating mode of operation (step **350**). Alteratively, as mentioned above, the heating mode of operation can be selected automatically by, for example, thermostatic control based on a predetermined difference in temperature inside and outside of the vehicle. This activates the controller **290**. Peltier modules **248**, the main exchanger fan(s) **254** and waste exchanger fan(s) **256** (step **352**).

The heating mode control logic **348** directs power at a maximum level to the Peltier modules, keeps the main fan(s) off, and operates the waste fan(s) at a high speed (step **354**). The temperature difference between a predetermined temperature (T_t) and the temperature of the conditioned air (T_c), via the temperature sensor **288** is monitored (step **356**). If the T_c is less than the T_t (step **358**), i.e., the temperature of the conditioned air is below the predetermined temperature, the level of power directed to the Peltier modules is maintained and the main fan(s) is off (step **354**). Like the heating mode control logic **314** for the first controlling method, maintaining maximum power to the Peltier modules while keeping the main fan(s), until a predetermined temperature is achieved, provides a rapid response from the time that the TCCS is activated to the time that a desired heating setpoint temperature is reached.

If the T_c is greater than the T_t (step **360**), i.e., the temperature of the conditioned air is higher than the predetermined temperature, the main fan(s) is operated at low speed (step **362**), maximum power to the Peltier modules is maintained (step **354**), and the temperature difference between T_t and T_s is continuously monitored (step **356**).

The heating mode control logic **348** monitors the difference in temperature between a setpoint heating temperature (T_s) and the T_c (step **364**). If the T_c is less than the T_s (step **366**), i.e., the temperature of the conditioned air is below the setpoint heating temperature, the main fan(s) speed is increased in proportion with increased T_c (**368**). For example, as the temperature of the conditioned air increases, the speed of the main fan(s) is increased. And conversely, as the temperature of the conditioned air decreases, the temperature of the main fan(s) is decreased. As the T_c approaches T_s, the temperature difference between the two are constantly monitored (step **364**).

If the T_c is equal to the T_s (step **370**), the power to the Peltier modules is switched on and off, in the manner described above for the fourth embodiment of the TCCS **238**, and the speed of the main fan(s) is unchanged (step **372**). Accordingly, unlike the heating mode control logic **314** of the first controlling method described above, the power is routed the Peltier modules at a maximum level and is switched on and off for heat output adjustment, rather than receiving a level of power proportional to the heating mode setting.

The heating mode logic **348** monitors the temperature of the heat pump (T_{hp}) **246**, by use of the temperature sensor **286**, and determines whether the T_{hp} exceeds a predetermined maximum temperature (T_m) (step **374**). If the T_{hp} is greater than the T_m, the power to the Peltier modules is shut off and the main fan(s) speed is maintained until the T_{hp} falls below the T_m (step **376**). A heat pump temperature above the predetermined maximum temperature indicates that a malfunction in the heat pump has occurred. Shutting off power to the Peltier modules ensures that a seated occupant will not be harmed or suffer discomfort as a result of such malfunction.

A third controlling method for use with the TCCS **238** described and illustrated above includes a heating mode control logic that is identical to the heating mode control logic **348** described above and illustrated in FIG. **14** for the second controlling method. FIG. **15** is a flow chart illustrating a cooling mode control logic **378** of the third controlling method used to operate the TCCS **238** in a cooling mode of operation. An occupant wishing to use the VTS **240** operates the control switch **284** to provide a desired cooling temperature, i.e., sets the control to a cooling mode of operation (step **380**). Alteratively, as mentioned above, the cooling mode of operation can be selected automatically by, for example, thermostatic control based on a predetermined difference in temperature inside and outside of the vehicle. This activates the controller **290**, Peltier modules **248**, the main exchanger fan(s) **254** and waste exchanger fan(s) **256** (step **382**).

The main fan(s) is operated at a speed proportional to the cooling mode setting (step **384**). For example, if the cooling mode setting is low, i.e., a relatively high cooling temperature, the main fan(s) is operated at a low speed. If the cooling mode setting is high, i.e., a relatively low cooling temperature, the main fan(s) is operated at a high speed. And if the cooling mode setting is medium, i.e., a moderate cooling temperature, the main fan(s) is operated at a medium speed. The waste fan(s) is operated at high speed (step **384**).

The cooling mode control logic **378** monitors the difference in temperature between the temperature of the conditioned air (T_c), via the temperature sensor **288**, and a setpoint cooling temperature (T_s) (step **386**). If the T_c is greater than the T_s (step **388**), i.e., the temperature of the conditioned air is above the setpoint cooling temperature, a maximum level of power is directed to the Peltier modules (step **390**), and the temperature difference between T_c and T_s is continuously monitored. If the T_c is less than the T_s (step **392**), a minimum level of power is directed to the Peltier modules (step **394**), and the temperature difference between T_c and T_s is continuously monitored. If the T_c is less than a predetermined minimum temperature (T_m) (step **396**), power to the Peltier modules is shut off and the main fan(s) speed remains unchanged (step **398**). A T_c below T_m indicates a malfunction in the heat pump and shutting off the Peltier modules ensures that a seated occupant will experience discomfort or harm from such malfunction.

If the T_c is equal to the T_s (step **400**), the power to the Peltier modules is switched on and off to maintain the T_s, the speed of the main fan(s) remains unchanged (step **402**), and the temperature difference between T_c and T_s is continuously monitored (step **386**). Accordingly, once the T_s is achieved, the power to the Peltier modules is adjusted, rather than the fan speed, to maintain the T_s. The cooling mode control logic **378** monitors the length of time that the Peltier modules have been operated and reduces the level of power directed to the Peltier modules to 10 to 25 percent of the original power level after a predetermined amount of time as passed (step **404**). The speed of the main fans remain unchanged (step **404**). In a preferred embodiment, the length of time is in the range of from 5 to 15 minutes. It is desired to decrease the amount of cooling provided to the VTS **240** after a predetermined amount of time to prevent overcooling

a seated occupant's back, which has been shown to cause occupant discomfort.

Although the cooling and heating mode control logic for the first, second, and third controlling methods have been described above as being used with the fourth embodiment of the TCCS **238**. It is to be understood that the first, second, and third controlling methods can be used with the other TCCS embodiments of this invention. For example, the first, second, and third controlling methods can be used to provide temperature conditioned air to a VTS configured to accommodate convective heat transfer to a seated occupant, as shown in FIG.

It is also to be understood that the embodiments of the TCCS described above and illustrated in FIGS. **1**, **4**, **6**, **8** and **11** have been presented in a form to promote clarity and understanding of the invention. Accordingly, the TCCS system may be configured differently than illustrated. For example, the heat pumps used to provide temperature conditioned air to the VTS can be mounted within the seat bottom and/or seat back of the VTS itself, rather than being mounted external to the VTS. Additionally, the controller and control switches can also be mounted within the VTS itself.

The embodiments of the TCCS described above and illustrated can also be configured to provide temperature conditioned air to more than one VTS. For example, the TCCS illustrated in FIGS. **1**, **4**, **6**, **8** and **11** can provide temperature conditioned air to a number of VTS seats using parallel air flow from one or more heat pumps operated by a respective TCCS heating and cooling control logic. Such an embodiment would be particularly useful in applications related to public transportation, such as planes, buses, trains and the like, where a number of occupants remain seated for extends period while traveling.

In addition to the embodiments of the TCCS specifically described above and illustrated, it is to be understood that such the TCCS may incorporate input from an energy management system, such as that used in electric powered vehicles. In specific embodiments, the TCCS is configured to accept an inhibit signal from such an energy management system. The inhibit signal is typically activated by a vehicle's energy management system under particular conditions of operation when an additional amount of energy is required or when the battery is being discharged to rapidly, such as during hard acceleration, when climbing a hill, or when the battery is weak or is approaching its minimum discharge voltage. The temperature climate control logic according to the present invention can be configured to deactivate the Peltier modules, the main exchanger fans, and the waste exchanger fans upon activation of the inhibit signal.

Accordingly, it is to be understood that, within the scope of the appended claims, the temperature climate control system according to principles of this invention may be embodied other than as specifically described herein.

What is claimed is:

1. A method for controlling the temperature climate in a variable temperature occupant seat, the method comprising the steps of:

selecting a temperature that effects a cooling mode of operation;

activating a number of thermoelectric modules to temperature condition a heat transfer medium to a desired cooling temperature;

activating at least one transporting means mounted adjacent the thermoelectric modules for passing temperature conditioned heat transfer medium from the modules to a variable temperature seat;

monitoring the temperature of the temperature conditioned heat transfer medium; and

automatically regulating both the amount of power directed to the thermoelectric modules, and an operating speed of the transporting means to achieve the desired cooling temperature.

2. The method as recited in claim **1** wherein the heat transfer medium is air and the transporting means is a fan.

3. The method as recited in claim **2** comprising the step of automatically operating the fan at a speed proportional to the desired cooling level.

4. The method as recited in claim **3** comprising the step of automatically operating the thermoelectric modules at a power level proportional to the desired cooling level.

5. The method as recited in claim **2** comprising the step of monitoring a difference in temperature between the temperature conditioned heat transfer medium and the desired cooling temperature.

6. The method as recited in claim **4** comprising the step of automatically regulating the amount of electrical power directed to the thermoelectric modules based on the temperature difference.

7. The method as recited in claim **6** comprising directing a maximum level of electrical power to the thermoelectric modules when the temperature of the temperature conditioned heat transfer medium is greater than the desired cooling temperature.

8. The method as recited in claim **6** comprising directing a minimum level of electrical power to the thermoelectric modules when the temperature of the temperature conditioned heat transfer medium is less than the desired cooling temperature.

9. The method as recited in claim **6** comprising switching the electrical power to the thermoelectric modules on and off when the temperature of the temperature conditioned heat transfer medium is equal to the desired cooling temperature to maintain the desired cooling temperature.

10. The method as recited in claim **3** comprising reducing the amount of electrical power directed to the thermoelectric modules if the desired cooling temperature has been achieved for a predetermined amount of time.

11. The method as recited in claim **10** comprising reducing the amount of electrical power directed to the thermoelectric modules in the range of from 10 to 25 percent.

12. A method for controlling the temperature climate in a variable temperature occupant seat, the method comprising the steps of:

selecting a temperature that effects a heating mode of operation;

activating a number of thermoelectric modules to temperature condition a heat transfer medium to a desired heating temperature;

activating at least one transporting means for passing the temperature conditioned heat transfer medium into a variable temperature seat;

monitoring the temperature of the temperature conditioned heat transfer medium; and

automatically regulating both the amount of power directed to the thermoelectric modules, and an operating speed of the transporting means to achieve the desired heating temperature.

13. The method as recited in claim **12** wherein the heat transfer medium is air and the transporting means is a fan.

14. The method as recited in claim **13** comprising directing electrical power at a maximum level to the thermoelec-

tric modules and not operating the fan if the temperature of the conditioned air is below the predetermined threshold temperature.

15. The method as recited in claim **14** comprising operating the fan at a low speed if the if the temperature of the conditioned air is at or above the predetermined threshold temperature.

16. The method as recited in claim **14** comprising monitoring a difference in temperature between the desired heating temperature and the temperature of the conditioned air.

17. The method as recited in claim **16** comprising increasing the speed of the fan proportionally with increasing temperature of the temperature conditioned air when the temperature of the temperature conditioned air is greater than the desired heating temperature.

18. The method as recited in claim **16** comprising switching the electrical power directed to the thermoelectric modules on and off when the temperature of the temperature conditioned air is equal to the desired heating temperature for maintaining the desired heating temperature.

19. The method as recited in claim **13** comprising directing electrical power to the thermoelectric modules at a level proportional to the desired heating level, and not operating the fan.

20. The method as recited in claim **19** comprising monitoring a temperature difference between a predetermined threshold temperature and the temperature of the temperature conditioned air.

21. The method as recited in claim **19** comprising operating the fan at low speed if the temperature of the conditioned air is greater than the predetermined threshold temperature.

22. The method as recited in claim **19** comprising monitoring a difference in temperature between the desired heating temperature and the temperature of the conditioned air.

23. The method as recited in claim **22** comprising operating the speed of the fan in proportion to the temperature of the temperature conditioned air when the temperature of the temperature conditioned air is less than or greater than the desired heating temperature.

24. The method as recited in claims **16** and **19** comprising monitoring the temperature of the heat pump and shutting of electrical power to the thermoelectric modules if the temperature of the heat pump is greater than a predetermined maximum temperature.

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United States Patent [19]

[11] **Patent Number: 4,923,248**

[45] **Date of Patent: May 8, 1990**

Feher

[54] **COOLING AND HEATING SEAT PAD CONSTRUCTION**

[76] Inventor: **Steve Feher,** 1909 Aleo Pl., Honolulu, Hi. 96822

[21] Appl. No.: **272,518**

[22] Filed: **Nov. 17, 1988**

[51] **Int. Cl.**[5] **A47C 7/74**

[52] **U.S. Cl.** **297/180**; 297/453; 5/469

[58] **Field of Search** 297/180, 453; 5/453, 5/469

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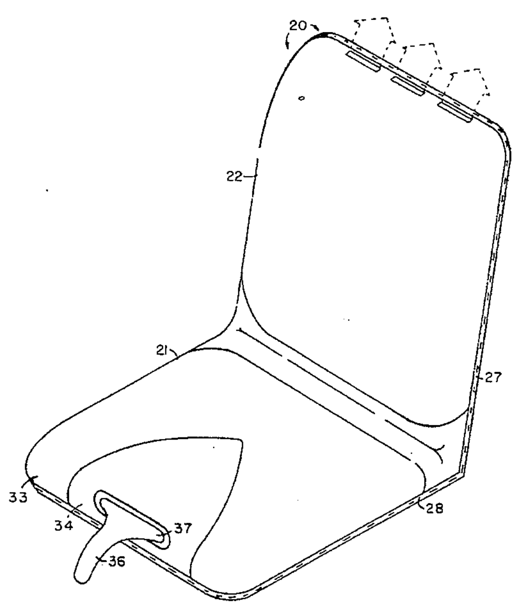
Primary Examiner—Peter R. Brown

Attorney, Agent, or Firm—George J. Netter

[57] **ABSTRACT**

A seat pad and backrest enclose a plenum into which pressurized air is provided from a closely adjacent Peltier air temperature and humidity modifying apparatus (either cooled or warmed). A metallic mesh is part of the seat pad and backrest and warms or cools the user by conduction. Alternatively, the seat pad and backrest can be separate each having its own plenum, and modified air is provided to both via a selectively adjustable proportioning valve. Yet another alternative unitarily incorporates a seat pad and backrest into a chair with a single plenum fed temperature modified air from a Peltier unit mounted on the chair.

12 Claims, 8 Drawing Sheets



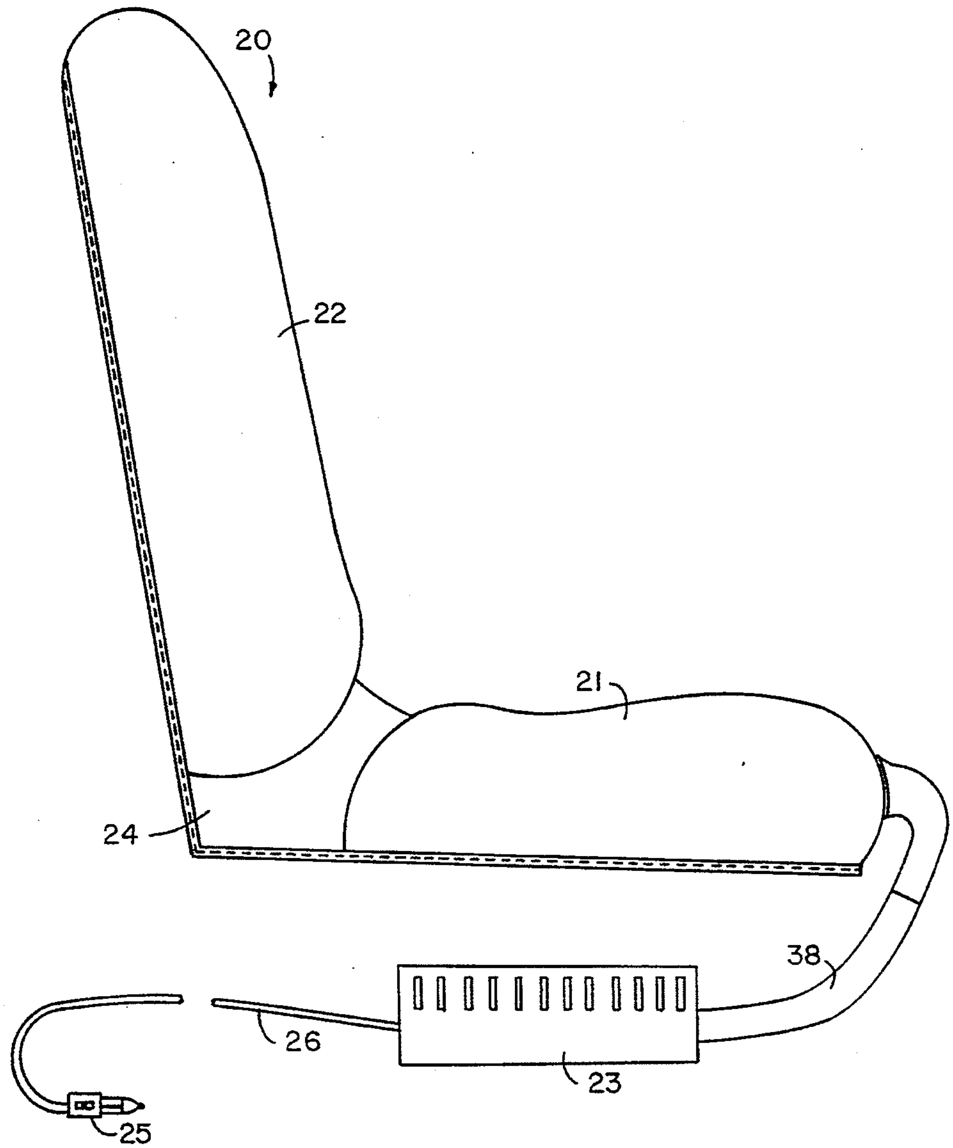


FIG. 1

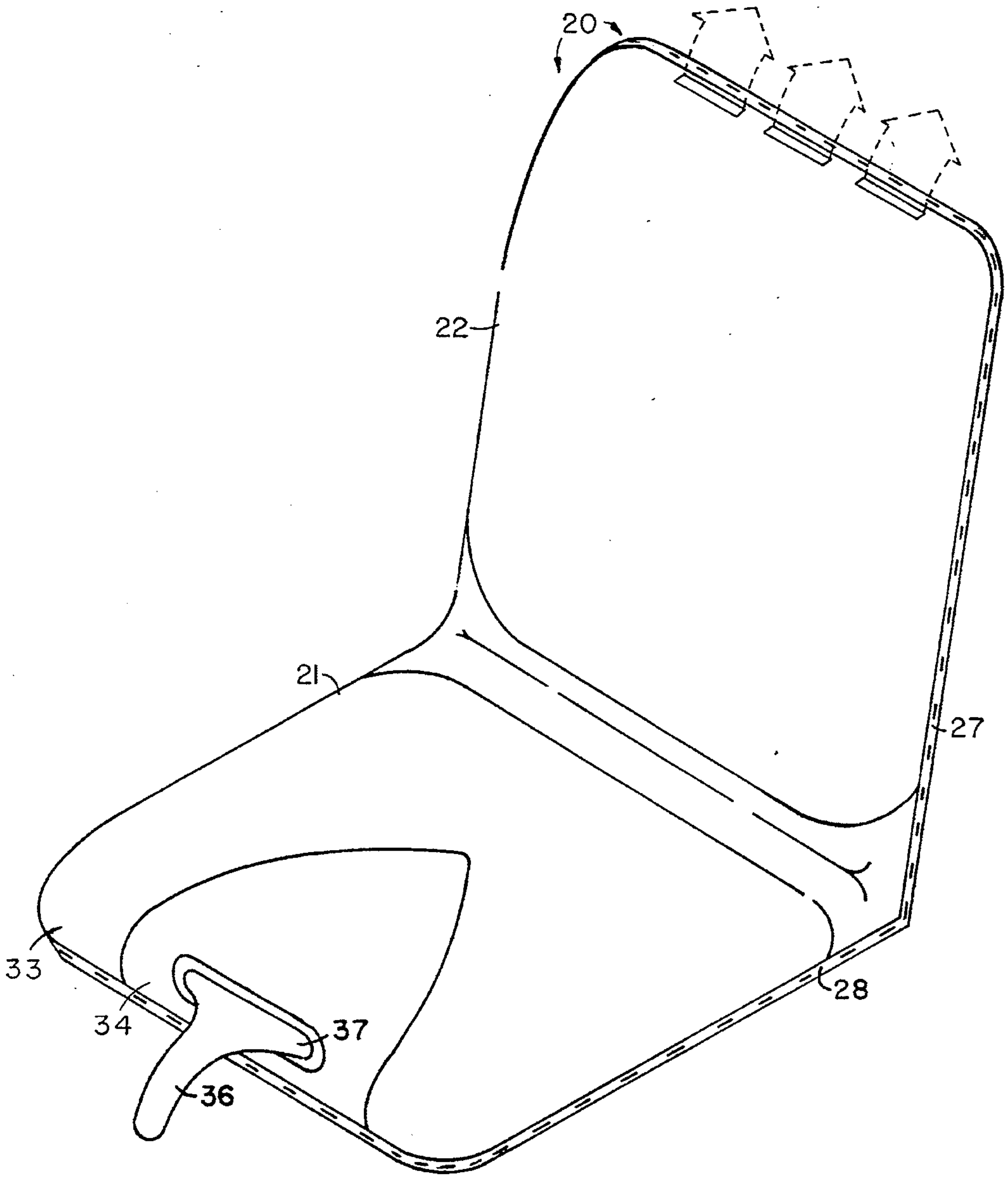


FIG. 2

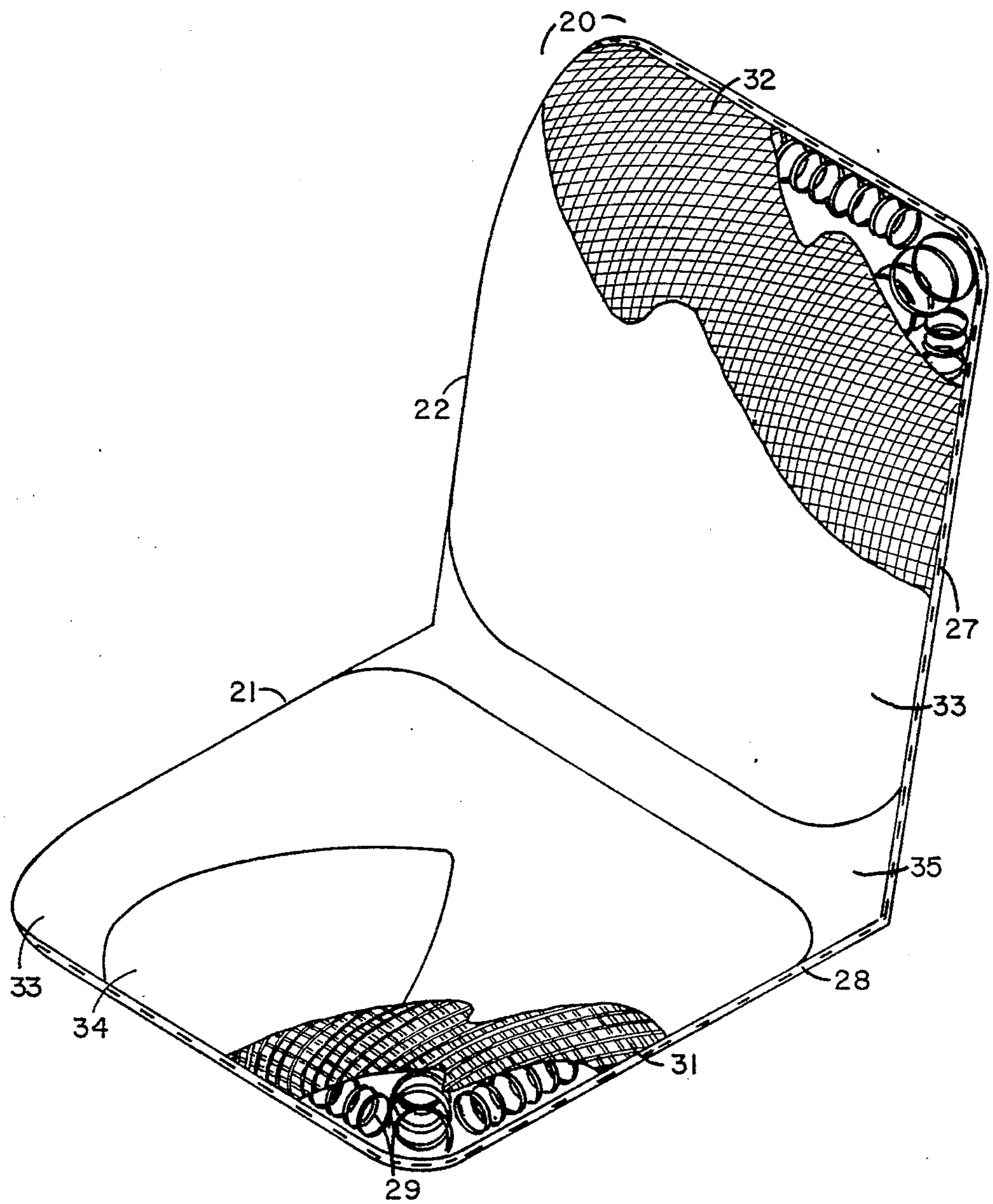


FIG. 3

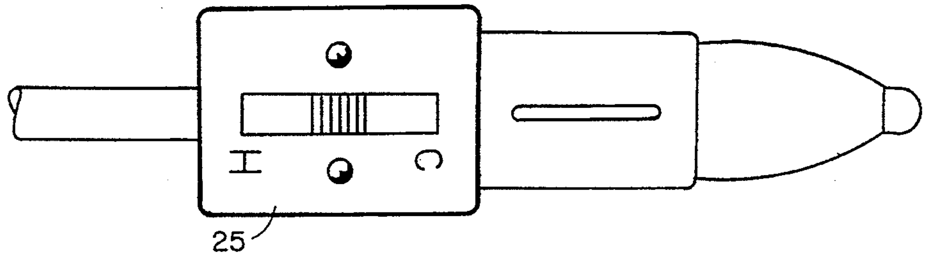


FIG. 11

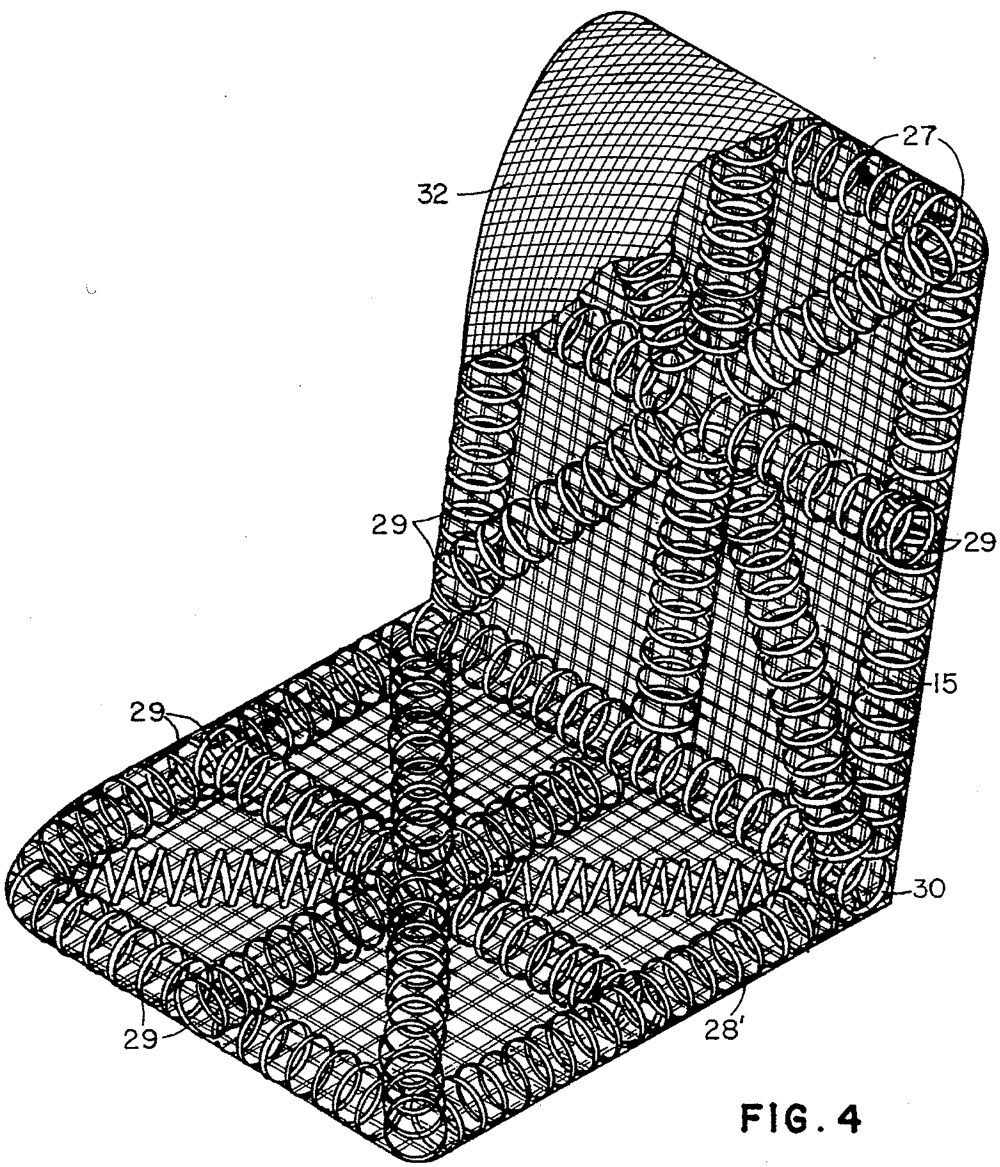


FIG. 4

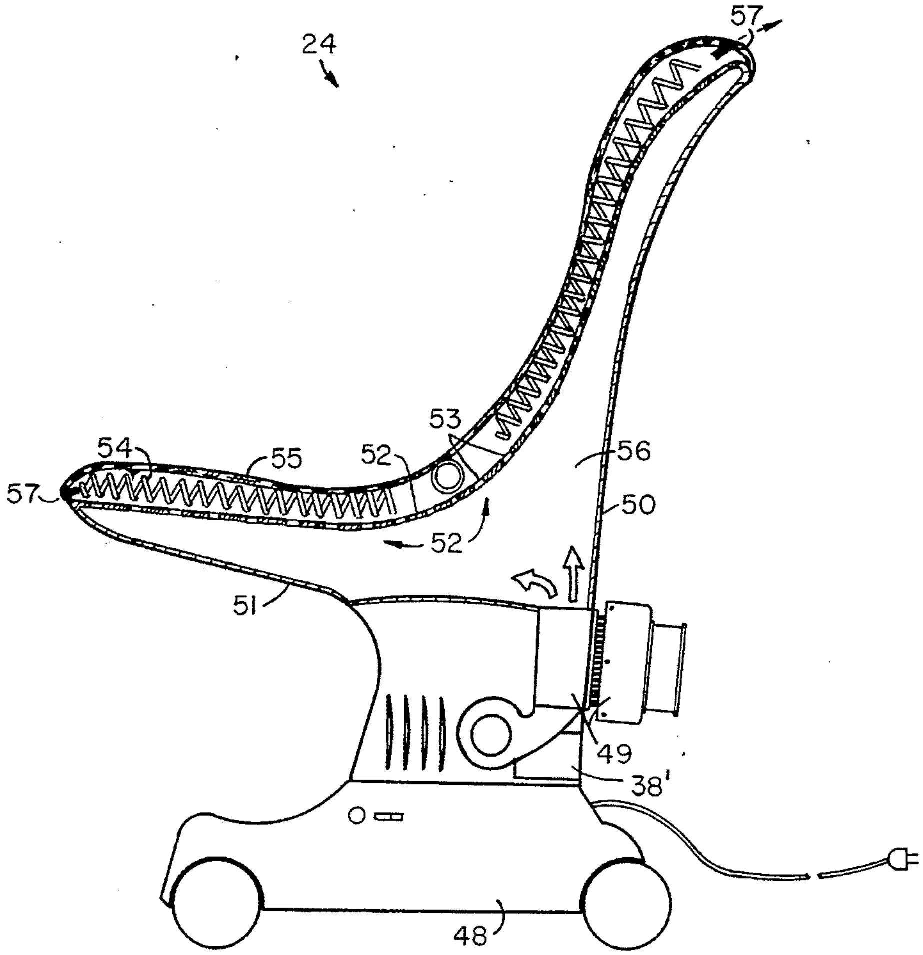


FIG. 5

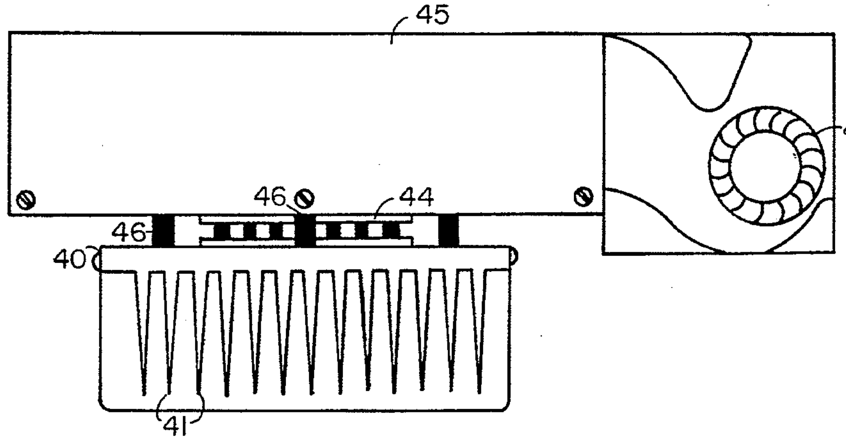


FIG. 6

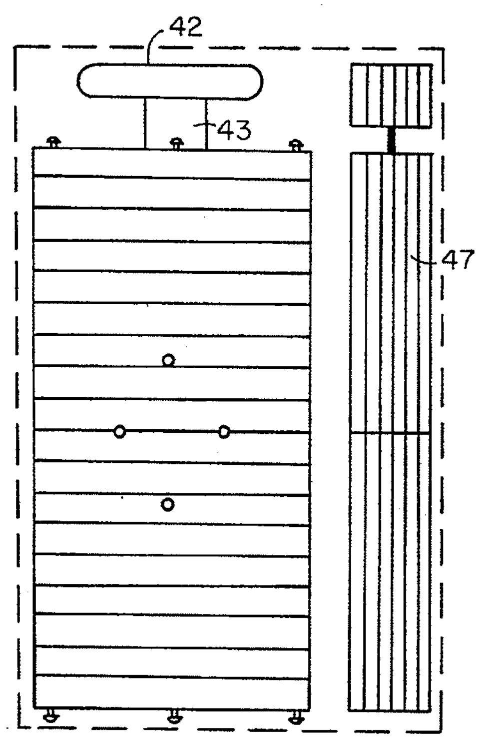


FIG. 7

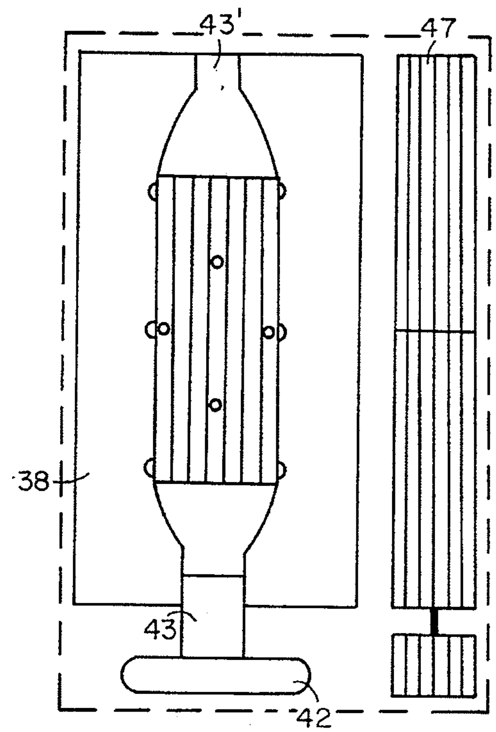


FIG. 8

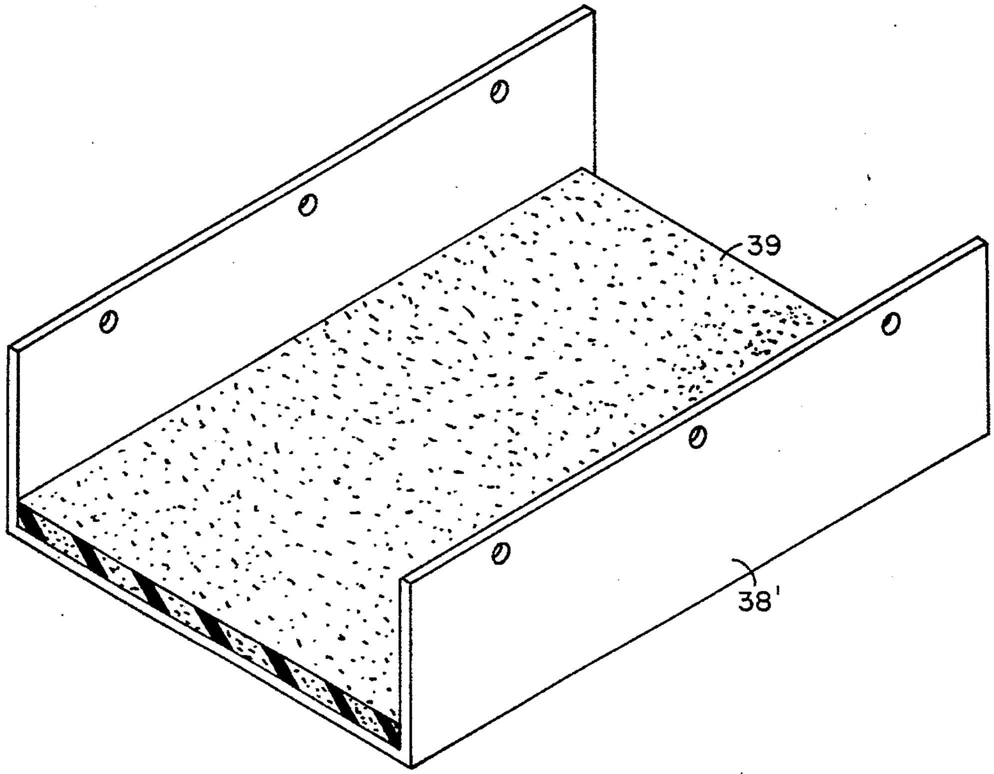


FIG. 9

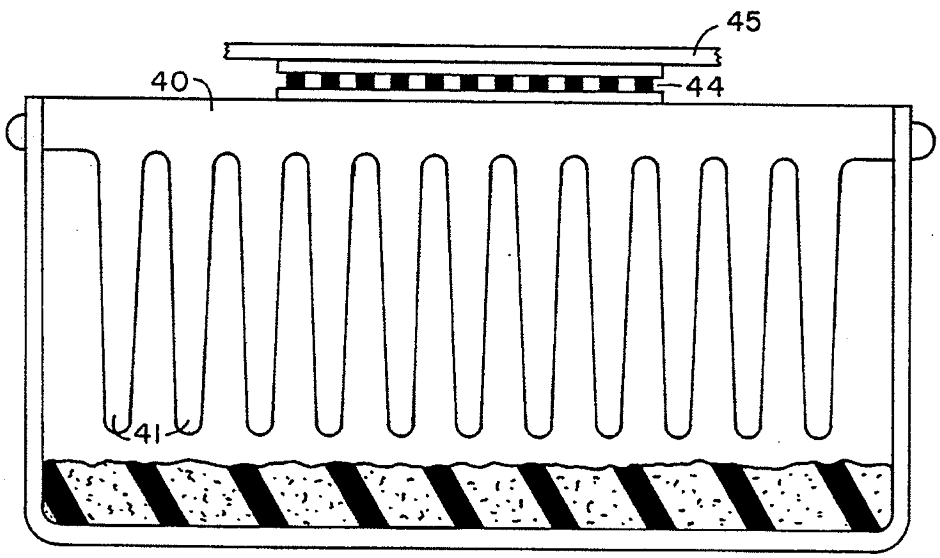


FIG. 10

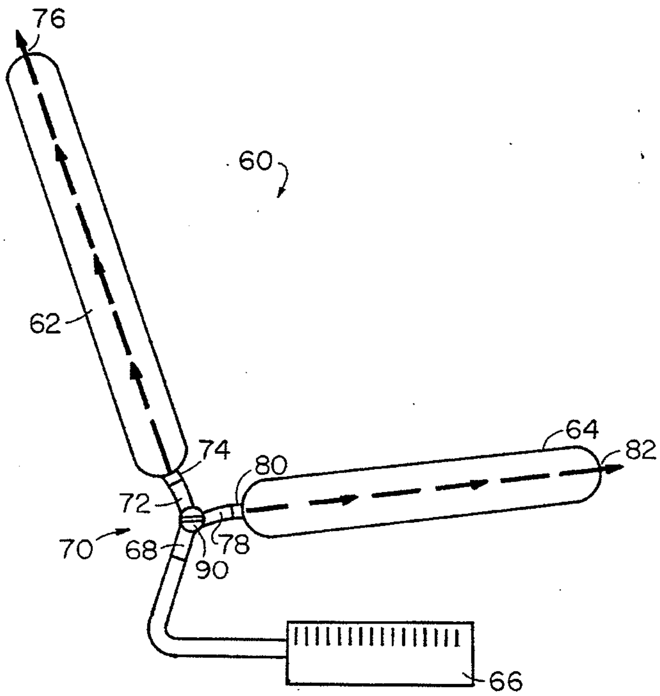


FIG. 12

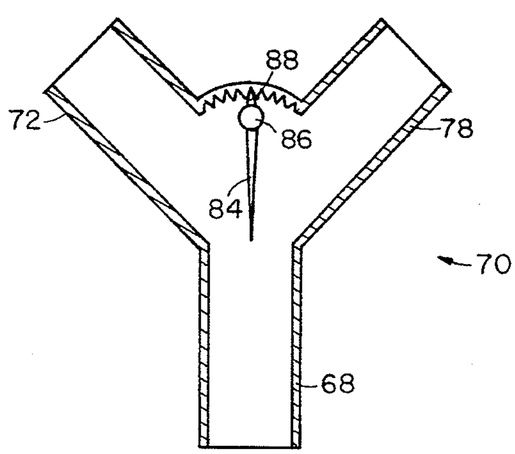


FIG. 13

COOLING AND HEATING SEAT PAD CONSTRUCTION

The present invention relates generally to a seat pad construction, and, more particularly, to a seat pad construction which can be selectively cooled or heated.

BACKGROUND

In the usual situation temperature modified air is provided to relatively extensive areas such as entire buildings, selected offices or suites of rooms within a building, or, in the case of automotive vehicles, the entire vehicle is cooled or heated as a unit.

There are many situations, however, in which more restricted air temperature modification, the ultimate use of which is to enhance the comfort of human beings, is desirable. For example, it may be desirable to provide a chair or seat, the immediate surroundings of which can be selectively cooled or heated, and yet the modified effect cannot be noted to any substantial extent beyond that range.

SUMMARY OF THE INVENTION

In accordance with the practice of the present invention there is provided a seat pad construction with air temperature modification apparatus for selectively providing heated or cooled air to the seat pad interior. The pad has back rest and seat portions including a plurality of coil spring elements arranged such that the weight of the user is exerted transversely against the planes of the spring coils. Several layers of air permeable material enclose the coil springs on the major surface facing an individual using the pad, and an air impermeable material is applied to the opposite major surface and sides. In addition, air flow barrier layers are located toward the front of the seat between the legs of a user and on the outer surface between the backrest and seat.

In this manner a plenum is formed between the back and the front surface of both the back rest as well as the seat portion into which air having its temperature modified by apparatus located conveniently adjacent is conduited via a fitting at the seat front.

It is contemplated that the seat pad construction could be placed on an automobile seat, a specialty chair such as a dentist's chair or other examination type chairs, or onto the usual overstuffed chair found in many homes. The energy requirements are modest since the area to be cooled or heated is relatively small, and the localized effect does not disturb others in the vehicle or room. This latter feature may be especially advantageous where a patient may have to be in a dentist's chair for an extended period of time and cooling/heating may increase the patient's comfort; however, the dentist or technicians working on the patient may not wish to be exposed to additional cooling or heating.

This invention is believed to be most advantageously employed in providing substantially instantaneous heating or cooling to the driver of an automotive vehicle In summer weather, it is a common experience on returning to a car which has been parked in an unshaded area for a long period of time to find the vehicle very hot and the seat feeling very uncomfortable for some time even with normal air conditioning. Also, in the wintertime, it may be highly desirable to have means such as the present invention for quickly warming the body until the vehicle heater is able to warm the vehicle interior.

The air modifying apparatus consists of a housing enclosing Peltier effect devices which can be selectively energized to heat or cool air passing thereover. There are two chambers, a first for providing air from the surrounding environment in contact with one surface of the Peltier effect devices where the temperature is modified and then further driving the air over a condensate trap to remove excess moisture before ultimate delivery to the seat pad. A second chamber in physical contact with another surface of the Peltier effect devices where air driven therepast by a tangential blower is heated in the cooling mode and it is this air which is directed back to the environment. Electricity for the apparatus can be obtained in the case of an automobile via cabling plugged into the cigarette lighter socket, for example, or directly from the vehicle electrical supply.

DESCRIPTION OF THE DRAWING

FIG. **1** is a side elevational view of a seat pad construction of the invention shown installed for use in an automotive vehicle seat.

FIG. **2** is a perspective view of the seat pad construction of this invention shown disconnected from the air temperature modifying apparatus.

FIG. **3** is a perspective view of the seat pad of FIG. **2** with portions thereof shown in sectional and fragmentary views.

FIG. **4** is a further perspective view of the seat pad construction with substantially all outer covering removed. FIG. **5** shows the seat pad construction adapted for use in a dental chair or treatment chair.

FIG. **6** is a side elevational view of the air modifying apparatus.

FIG. **7** is a top plan view of the apparatus of FIG. **6**.

FIG. **8** is a bottom plan view of the apparatus of FIG. **6**.

FIG. **9** is a perspective view of a housing shell including a condensate trap.

FIG. **10** is an end view of the housing of FIG. **9** shown with apparatus mounted therein.

FIG. **11** is an elevational enlarged view of the electrical switch and socket for use with the air temperature modifying apparatus.

FIG. **12** is a side elevational view of yet another embodiment of the seat pad construction.

FIG. **13** is an elevational sectional view of a valving means for use in the FIG. **12** embodiment.

DESCRIPTION OF A PREFERRED EMBODIMENT

Turning now to FIGS. **1** and **2** of the drawing, the seat pad construction of the present invention is enumerated generally as **20** and generally includes an elongated pad having a seat portion **21** and unitary backrest **22**. An internal plenum is provided with conditioned or temperature and humidity modified air by an externally located Peltier heating/cooling apparatus **23** which is preferably electrically powered. The seat pad construction **20** can be integrally built into a seat or chair **24** (FIG. **5**) or may be separate and merely resting on the seat or chair. In an automotive vehicle, electricity can be provided by the cigarette lighter through a suitable socket **25** and cabling **26**.

For the ensuing detailed seat pad construction aspects, reference is now additionally made to FIGS. **2** through **4**. As shown there, the external rear surface for both the back rest **22** and seat portion **21** includes air-tight, but not exceptionally rigid, plates or sheets **27** and

28, respectively, of an air impermeable material. These plates are secured together into a generally L-shaped relation with some ability to rotate about the junction between the backrest and seat so as to conform to most seats or chairs. The inner surfaces of the plates **27** and **28** are covered with a tightly woven plastic fibers mesh **28'** (FIG. **4**).

Onto the mesh **28'** over each of the plates **27, 28** there are a plurality of helically wound coil springs **29** arranged as spokes in a wheel with inner ends at substantially the center points, respectively, of the backrest and seat. Interconnection of the springs is accomplished by coiling the loop ends together, or alternatively by the outer ends secured by stapling, for example, or any other convenient manner to the plates **27** and **28**. The spring coils, when arranged as described, receive the weight of a user of the seat construction transversely of the coil loops in both the seat and backrest portions without closing off the plenum. A further spring coil **30** is arranged along the junction of the two plates **27** and **28** and in the same manner as springs **29** prevents a closing-off of the space between the backrest and seat portion and yet allows a hinge action to take place there.

A sheet of fine plastic mesh **31** which is moderately permeable by air covers over the top surface of the coil springs in the seat portion **21** and has its edges secured to the plate **28** (FIG. 3). The plastic mesh extends up to the region dividing the seat portion from the backrest. The springs in the backrest are stretchably covered by aluminum or copper open mesh **32** which, in addition to acting as a means for spreading the applied pressure over the underlying springs, also because of its greater heat conduction properties than plastic, establishes a layer against a user's back which rapidly follows temperature changes of the air in the backrest plenum. An extent of slightly permeable woven fabric **31** is then applied over the layers **31** and **32**, and affixed at the edges of the plates **27** and **28** by stapling or any other suitable means. This outer fabric can be colored or provided with any desirable designs for aesthetic purposes as long as the air permeability is not cut off.

Two areas **34** and **35** are covered with an air flow barrier material such as silkscreened latex, for example. Area **34** coincides with the space typically lying between a user's legs and area **35** is along the pad hinge region between the seat and backrest, both of which do not normally require temperature adjustment. At the uppermost edge of the backrest a plurality of vents **35'** are provided via which pressurized temperature modified air passing through the seat pad exits to the environment.

Toward the front of the seat portion **21** and closely adjacent the front edge, there is provided a short length of conduit **36** (FIGS. **1** and **2**) having an open outer end which is secured to the underlying mesh via an enlarged portion **37**. The conduit **36** is releasably connected to the Peltier apparatus **23** by hosing **38** via which temperature modified air is pumped to the interior of the seat construction.

Turning now to FIG. **9**, the apparatus **23** for producing temperature modified air for the seat pad construction is mounted in a generally pan shaped housing **38'** having a bottom, side walls and an open top, and resting on the bottom of which is a porous foam rubber or plastic member **39**. In a way that will be more particularly described the member **39** absorbs moisture and in that way serves as a condensate trap.

A metal heat exchanger **40** having a plurality of fins **41** extending from one major surface is mounted in the housing **38'**, the fins extending downwardly with their outer edges spaced just above the condensate trap **39**. As can be seen best in FIG. **8**, environmental air is passed through a filter **42** by an axial blower **43** and then over the heat exchanger fins **41** where it is conditioned. The cooled or heated air exits at openings **43'** which is connected to the seat construction conduit **36** via a suitable length of hosing **38**.

With reference now to FIGS. **6** and **10**, there is shown a plurality of Peltier stacks enumerated collectively as **44**, one surface of which is maintained in good contacting heat conductive relation to the outer surface of the heat exchanger **40**. The other surface of the Peltier plates are in good heat conducting contact with an open ended chamber **45** mounted to the base plate of the heat exchanger by screws **46** as shown in FIG. **6**. A tangential cross-flow blower **47** mounted conveniently adjacent one end of the chamber moves air through the chamber which serves to dissipate heat absorbed by the cold side during cooling mode, and to supply heat from ambient air to the hot side when in the heating mode. As is well known to those skilled in the art, switching polarity of energizing voltage to the Peltier stacks changes what is the cold side in cooling mode to the hot side in heating mode.

The apparatus **23** (FIG. **1**) can be constructed in a relatively flat pack arrangement enabling location under an automobile front seat, for example, and thus out of the way.

In use of the seat pad construction described in an automotive vehicle environment, the electrical jack **25** can be plugged into the dashboard cigarette lighter (not shown) or, alternatively, it may be directly interconnected to the automobile electrical system. With the power switch set to either cooling (C) or heating (H) as shown in FIG. **12**, the axial blower **43** and horizontal blower **47** begin to operate which sets a reference temperature in the chamber **45** against which the Peltier plates then begin to cool or warm, depending upon the electrical setting of the energization equipment. The temperature modified air then passes outwardly along hose **38** from the apparatus **23** through the conduit **36** and into the plenum formed in the seat and backrest providing a seat and backrest portion which, depending upon the situation, either cools or warms an individual using the seat pad.

In a practical construction of the present invention, the mesh **31** for the seat portion was a 50×50 mesh using 0.020 inch diameter plastic fibers. For the backrest layer **32** a 40×40 mesh constructed of 0.010 inch diameter copper wire was used. The purpose of the metal mesh in the backrest is to compensate for the loss in Δ t between the seat and the backrest (i.e., air heat absorption in the seat). That is, thermal exchange efficiency must be better in the backrest than in the seat. A Peltier thermoelectric module, CP-1.4-127-045L manufactured by Melcor, Inc., Trenton, New Jersey, provided the desired air temperature modification with an axial blower delivering 4–6 cubic feet per minute.

Although the invention is described particularly in connection with use in an automotive vehicle, it can also be advantageously employed with office chairs, or patient examination chairs as shown in FIG. **5**, for example. Such a chair **24** would typically include a wheeled base **48**, although it could be fixedly secured to any suitable ground plane. The air modifying apparatus

49 is mounted onto the base **48** and can be identical to the apparatus **23** described in connection with the first embodiment. The chair further includes air impermeable back and bottom plates **50** and **51**. A one-piece, generally L-shaped seating support surface **52** is constructed of a relatively rigid plate having a large number of openings **53** distributed over its surface. A set of coil springs **54** identical to springs **29** and **30** of the first described embodiment are enclosed with mesh fabric layers as in the first version. In use, pressurized temperature and dehumidified air from apparatus **49** is passed into the plenum **56** defined by **50**, **51** and **52** and then through openings **53** to the seat pad proper for providing a cooled or heated surface, as the case may be, to the user. Vents **57** serve to exit air from the interior.

A still further embodiment of the present invention depicted in FIG. **12** pertains to a seat construction enumerated generally as **60** having separate backrest and seat pads **62** and **64**, respectively, which are selectively adjustable to cool or warm the user, as desired. The pads **62** and **64** can be constructed identically to the embodiment of FIGS. **3** and **4**, for example, in that each includes coil springs similar to springs **29** enclosed by mesh and fabric as described to enclose a plenum and provide an outer heat transferring surface for contacting the user. Temperature modified air obtained from apparatus **66**, which can be identical to apparatus **23**, is provided to an entrance end **68** of a Y-fitting **70**. A first fitting exit **72** communicates temperature modified air through a flexible hose **74** and through the lower edge wall of the backrest pad **62** into the interior plenum, which air leaves the backrest pad through one or more vents **76** located on the upper edge of **62**.

A second fitting exit **78** interconnects with the back edge of the seat pad **64** through a flexible hose **80**, the temperature modified air leaving the seat pad plenum via one or more vents **82** at the front or leading edge of the seat pad.

As shown in the Y-fitting sectional view of FIG. **13**, a flap valve **84** rotatably mounted on shaft **86** can be adjusted from a first extreme where the exit fitting **72** is closed from all temperature modified air from apparatus **66** to a second extreme where exit fitting **78** is closed off from passing air to the seat pad. In between the two extreme adjustments, temperature modified air is proportioned to the seat and backrest pads depending upon the valve setting. A detent pin **88** on the flap valve moves along and in contact with detent teeth in the inner surface of the Y-fitting wall between exits **72** and **78** to provide a positive adjustment setting for the valve. A control knob **90** enables manual adjustment of the valve to achieve the desired proportion of cooling/warming between the seat and backrest pads desired.

What is claimed is:

1. A seat pad construction for receiving temperature conditioned pressurized air and have its temperature modified accordingly, comprising:

first and second air-tight plate means hingedly interconnected along an edge in a generally L-shaped configuration defining the seat and backrest, respectively;

first spring means overlying the facing major surfaces of the first and second plate means;

second spring means extending along the interconnection of the first and second plate means;

a first air permeable material consisting of plastic mesh overlying the first spring means applied over the first plate means and secured to the first plate means edges;

a second air permeable material consisting of a copper wire mesh overlying the first spring means applied over the second plate means and secured to the second plate means edges;

a first air flow barrier located over the second spring means and edge interconnected with both the first and second air permeable materials:

a second air flow barrier located on the first spring means in the central leading top edge portion of the first plate means secured to both an edge of the first plate means and the first air permeable material: and

means mounted onto the second air flow barrier for interconnecting a source of pressurized modified air to the seat pad plenum defined by the first and second plate means covered by the first and second air permeable materials and the first and second air flow barriers.

2. A seat pad construction as in claim **1**, in which the first spring means include a plurality of helical coil springs arranged with the planes of the spring loops substantially normal to the major surface planes of the first and second plate means.

3. A seat pad construction as in claim **1**, in which the second spring means consists of a helically wound coil spring, the planes of the coil loops being arranged substantially normal to the interconnection edges of the first and second plate means.

4. A seat pad construction as in claim **1**, in which the means for interconnecting includes an open-ended length of tubular conduit.

5. A seat pad construction as in claim **1**, in which a layer of a closely woven plastic mesh is located between the first spring means and the first and second plate means.

6. A seat pad construction as in claim **1**, in which the pressurized air is conditioned by Peltier heating/cooling means.

7. Apparatus for selectively cooling or heating an automotive vehicle seat, comprising:

a seat pad having a seat and backrest portions with an enclosed plenum extending throughout the seat and backrest portions, the major surfaces of the seat pad facing outwardly in a direction toward a user including an air permeable covering having first heat condition properties in the seat portion and second heat conduction properties in the backrest portion greater than the first heat conduction properties, and the major surfaces facing away from a user being air-tight;

the air permeable covering being secured to the edges of said seat and backrest portions to define said plenum;

a selectively energizable Peltier unit for providing pressurized temperature modified air; and

conduit means interconnecting the Peltier unit and the seat pad plenum.

8. Apparatus as in claim **7**, in which the Peltier unit is so shaped and dimensioned as to enable locating under an automotive vehicle seat, and means are provided for energizing the Peltier unit by the vehicle electrical system.

9. Apparatus as in claim **8**, in which the Peltier unit includes electric cable means with a jack at one end for receipt within a vehicle cigarette lighter socket.

10. Apparatus as in claim 7, in which the seat pad rests upon a vehicle seat, and the seat and backrest are hinged so as to conform to the vehicle seat.

11. Apparatus as in claim 7, in which the Peltier unit includes a tangential blower for moving ambient air across a heat exchanger and a spongelike condensate trap.

12. A seat pad construction for receiving temperature conditioned pressurized air and have its temperature modified accordingly, comprising:

first and second air-tight plate means hingedly interconnected along an edge in a generally L-shaped configuration defining the seat and backrest, respectively;

first spring means overlying the facing major surfaces of the first and second plate means;

second spring means extending along the interconnection of the first and second plate means;

a first air permeable material consisting of plastic mesh overlying the first spring means applied over

the first plate means and secured to the first plate means edges;

a second air permeable material consisting of an aluminum wire mesh overlying the first spring means applied over the second plate means and secured to the second plate means edges;

a first air flow barrier located over the second spring means and edge interconnected with both the first and second air permeable materials;

a second air flow barrier located on the first spring means in the central leading top edge portion of the first plate means and the first air permeable material; and

means mounted onto the second air flow barrier for interconnecting a source of pressurized modified air to the seat pad plenum defined by the first and second plate means covered by the first and second air permeable materials and the first and second air flow barriers.

* * * * *

US007587901B2

(12) **United States Patent**
Petrovski

(10) **Patent No.: US 7,587,901 B2**
(45) **Date of Patent: Sep. 15, 2009**

(54) **CONTROL SYSTEM FOR THERMAL MODULE IN VEHICLE**

(75) Inventor: **Dusko Petrovski**, Washington, MI (US)

(73) Assignee: **Amerigon Incorporated**, Northville, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 467 days.

(21) Appl. No.: **11/047,077**

(22) Filed: **Jan. 31, 2005**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 60/637,725, filed on Dec. 20, 2004.

(51) **Int. Cl.**
F25B 21/02 (2006.01)

(52) **U.S. Cl.** **62/3.3**; 62/3.61

(58) **Field of Classification Search** 62/3.3, 62/3.7, 3.61, 261
See application file for complete search history.

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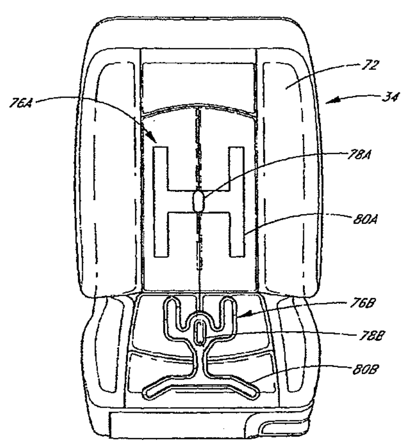
Primary Examiner—Melvin Jones
(74) *Attorney, Agent, or Firm*—Knobbe Martens Olson & Bear LLP

(57) **ABSTRACT**

A climate control device includes a first and a second thermal module. The first module is configured to provide climate conditioned air to a first portion of a seat. The second module is configured to provide climate conditioned air to a second portion of the seat. A control system is provided for controlling the climate control device. The control system includes an input device for providing a set point for the system. A first control unit of the control system is provided for the first thermal module and a second control unit is provided for the second thermal module.

23 Claims, 8 Drawing Sheets



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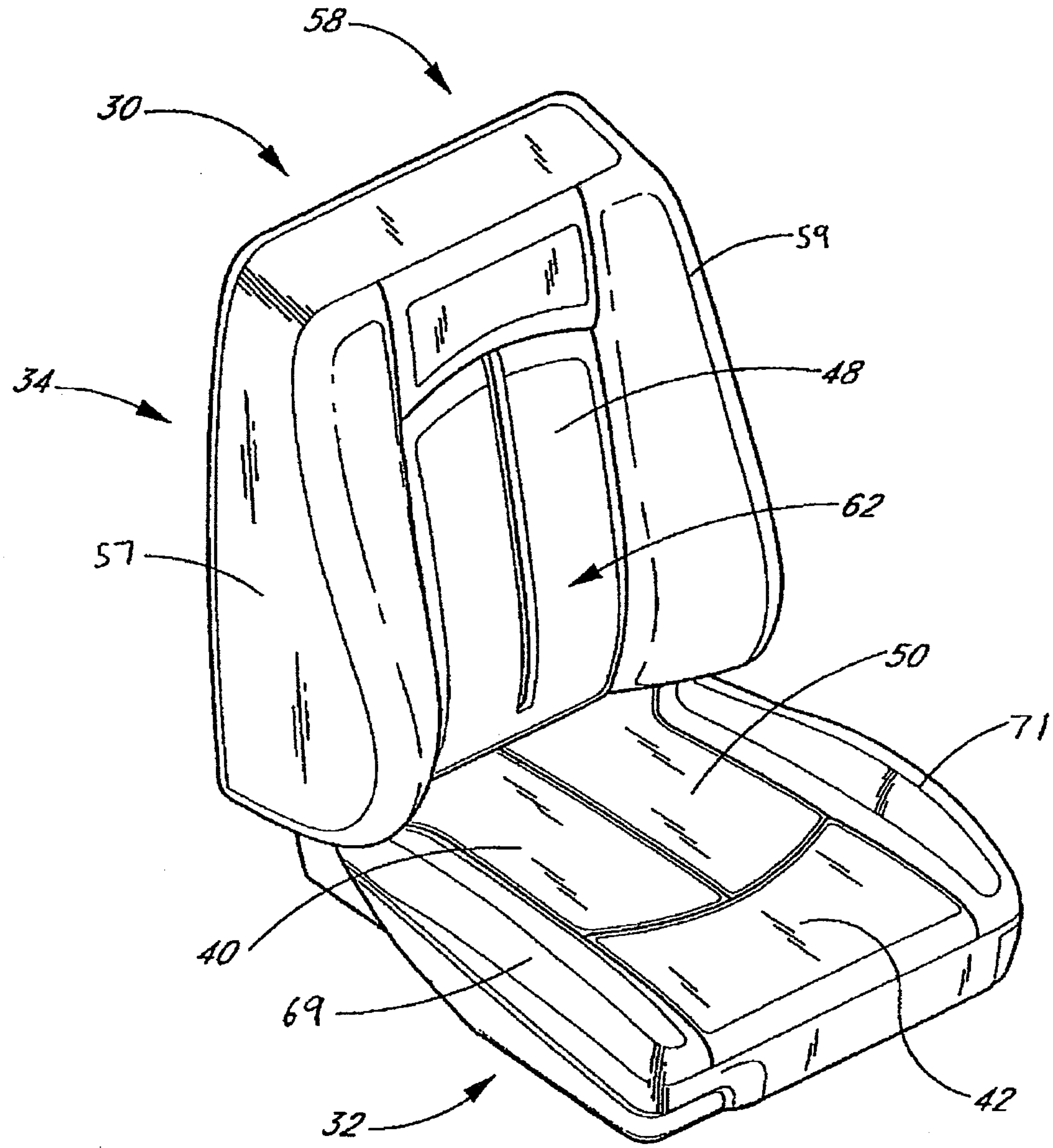

FIG. 1

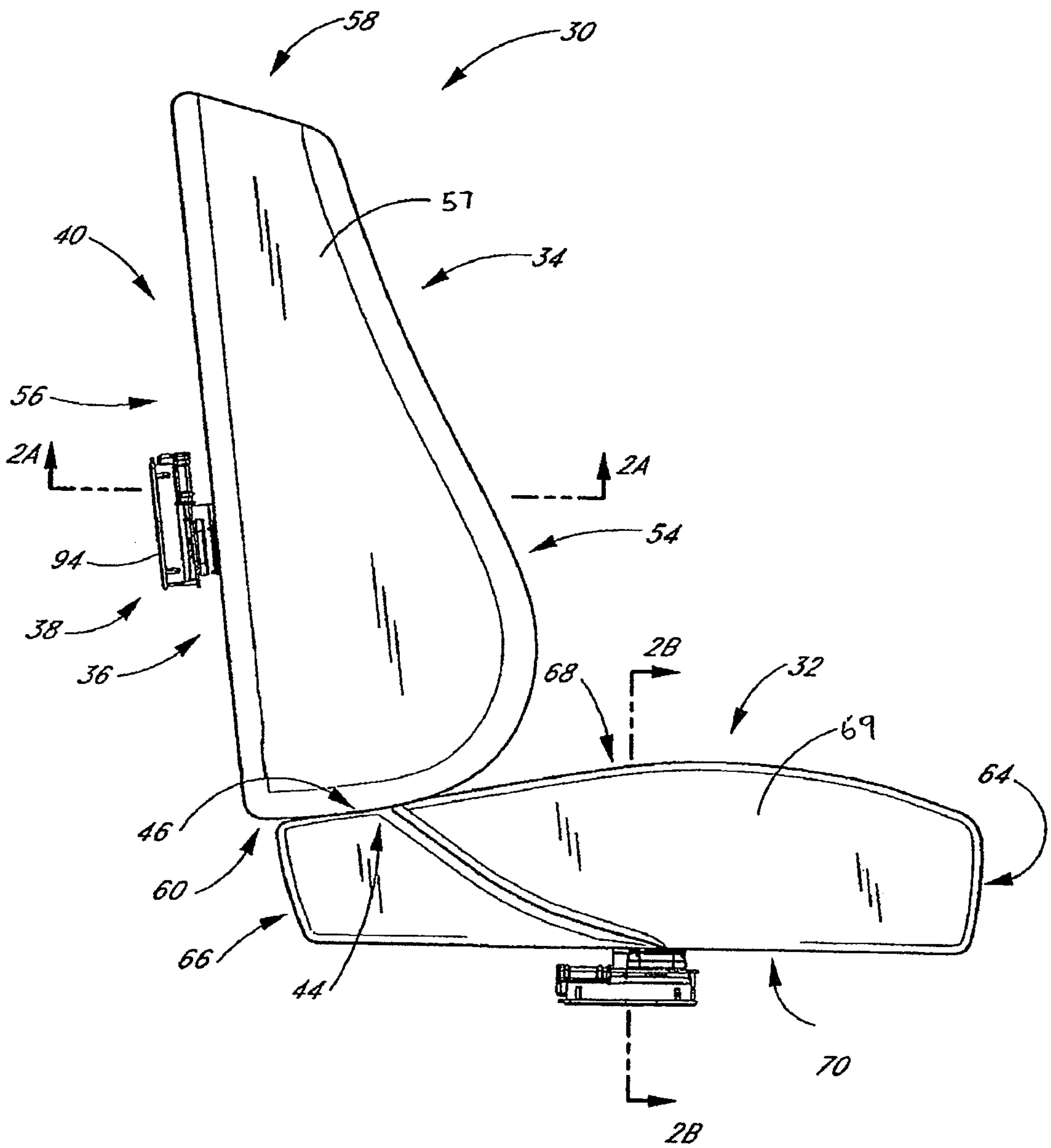

FIG. 2

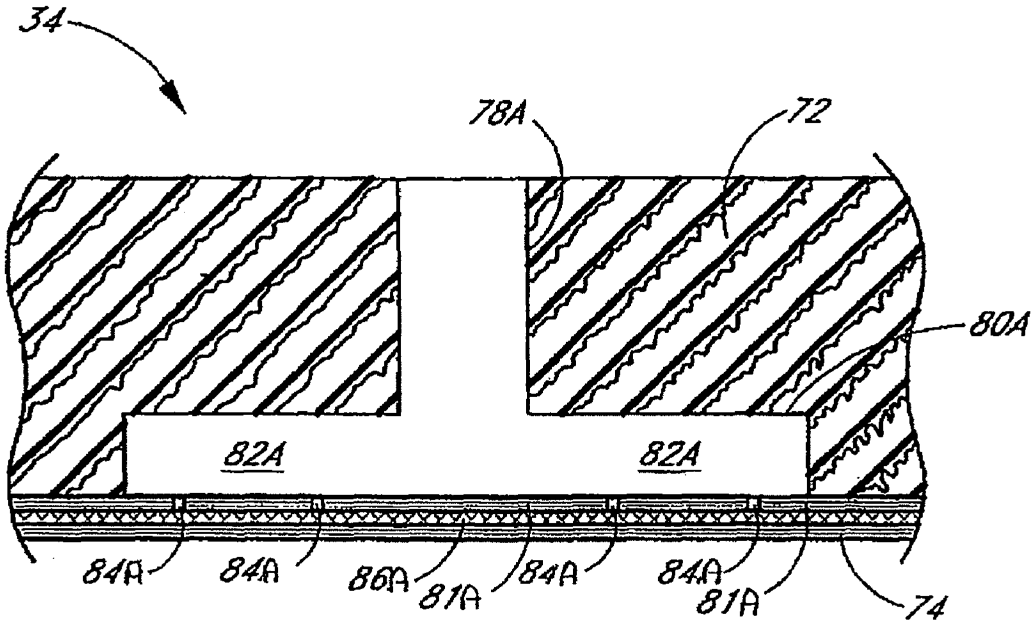
34
78A
72
80A
82A
82A
84A
84A
86A
81A
84A
84A
81A
74

FIG. 2A

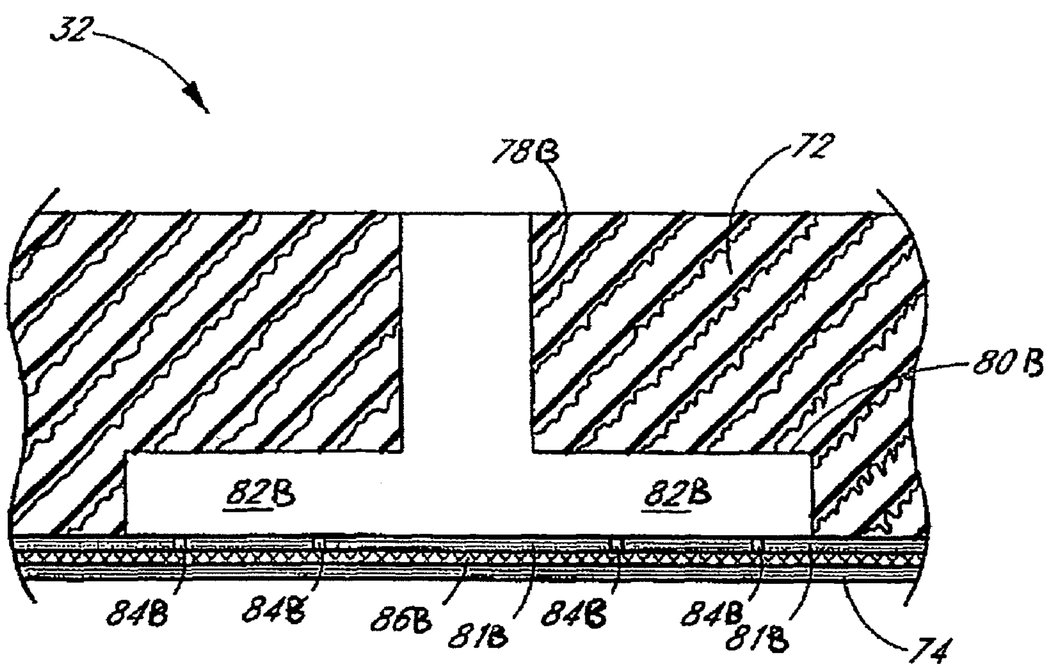
32
78B
72
80 B
82B
82B
84B
84B
86B
81B
84B
84B
81B
74

FIG. 2B

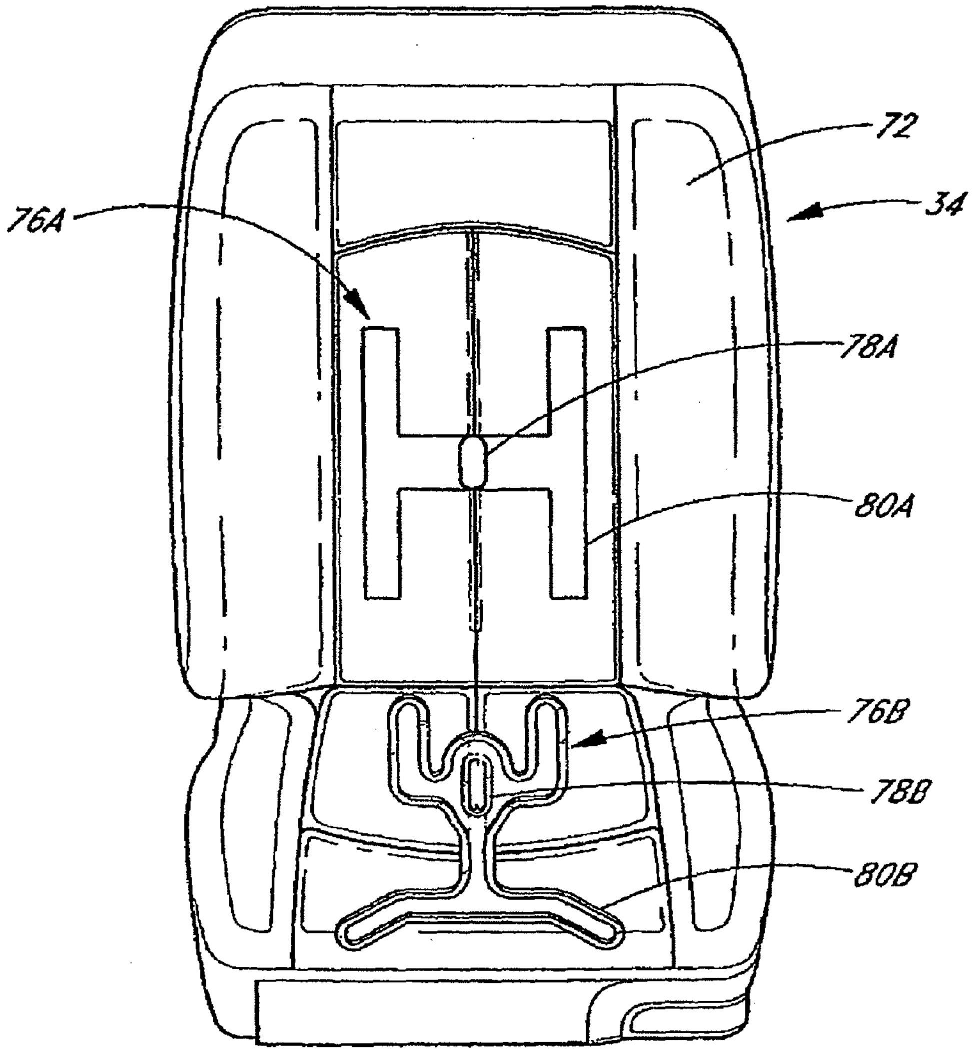

FIG. 3

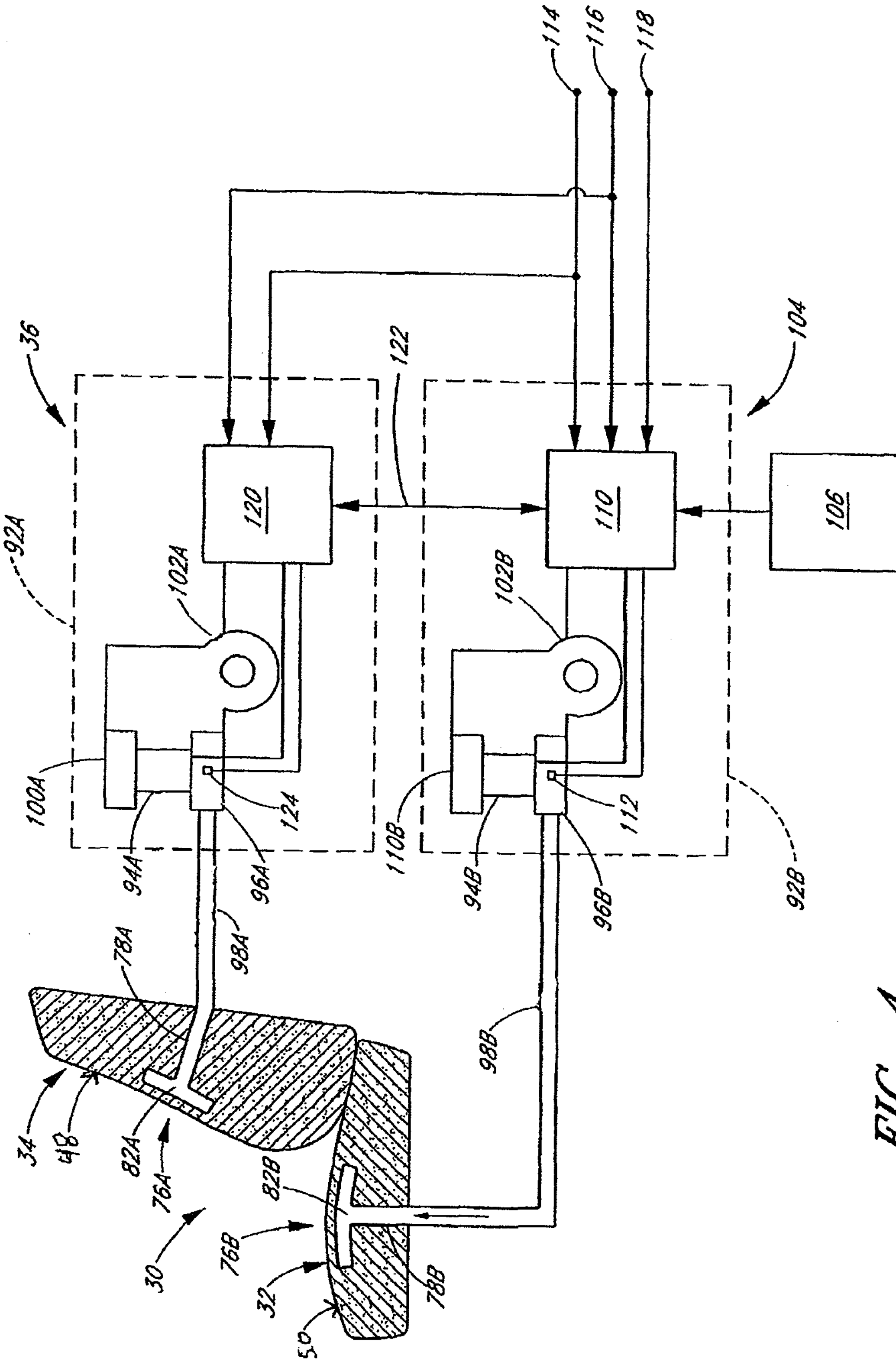
114
116
118
36
122
104
92A
120
110
106
102A
102B
100A
124
94A
96A
110B
112
94B
96B
92B
78A
98A
98B
34
48
82A
76A
30
82B
76B
32
50
78B

FIG. 4

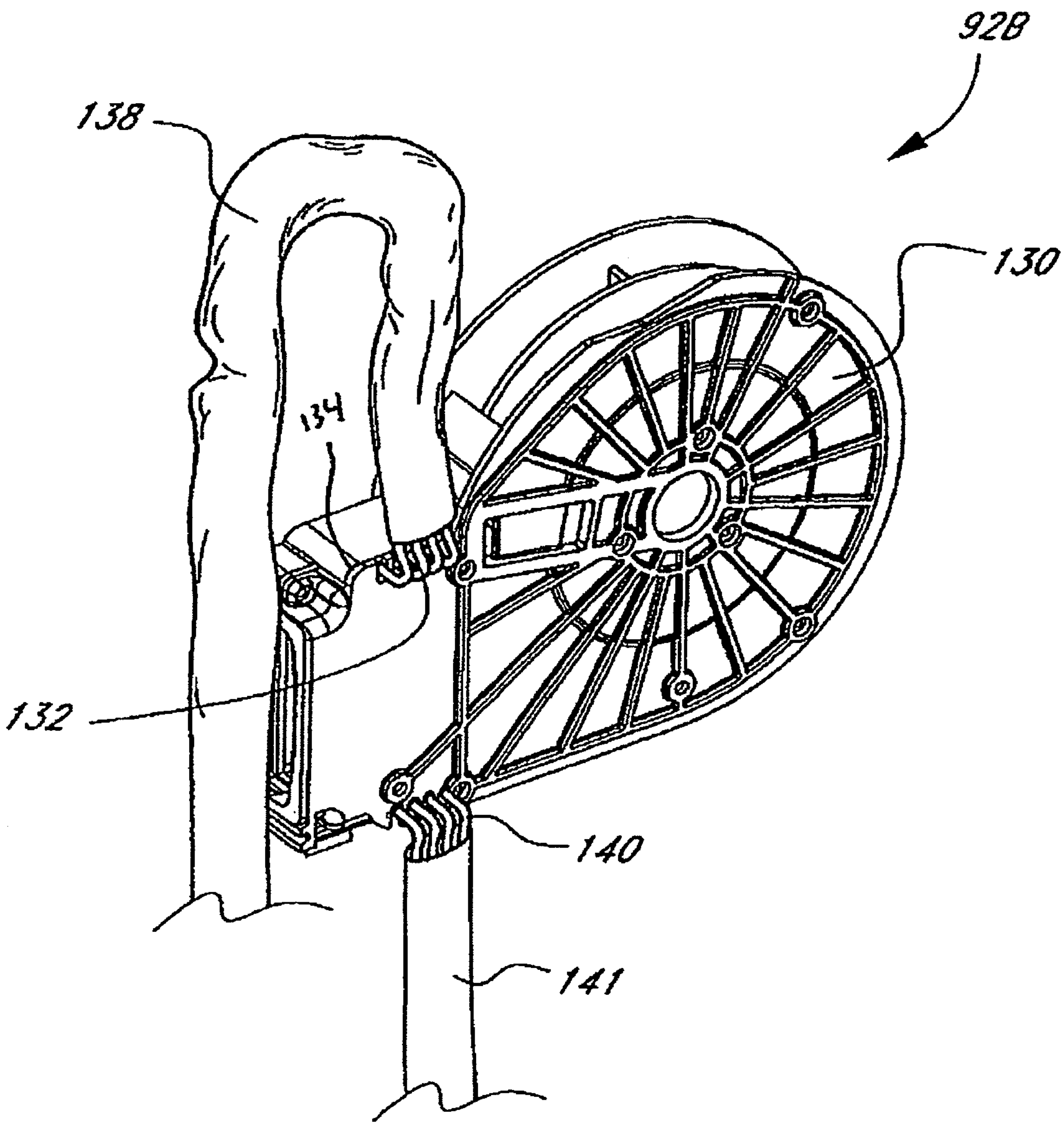

FIG. 5

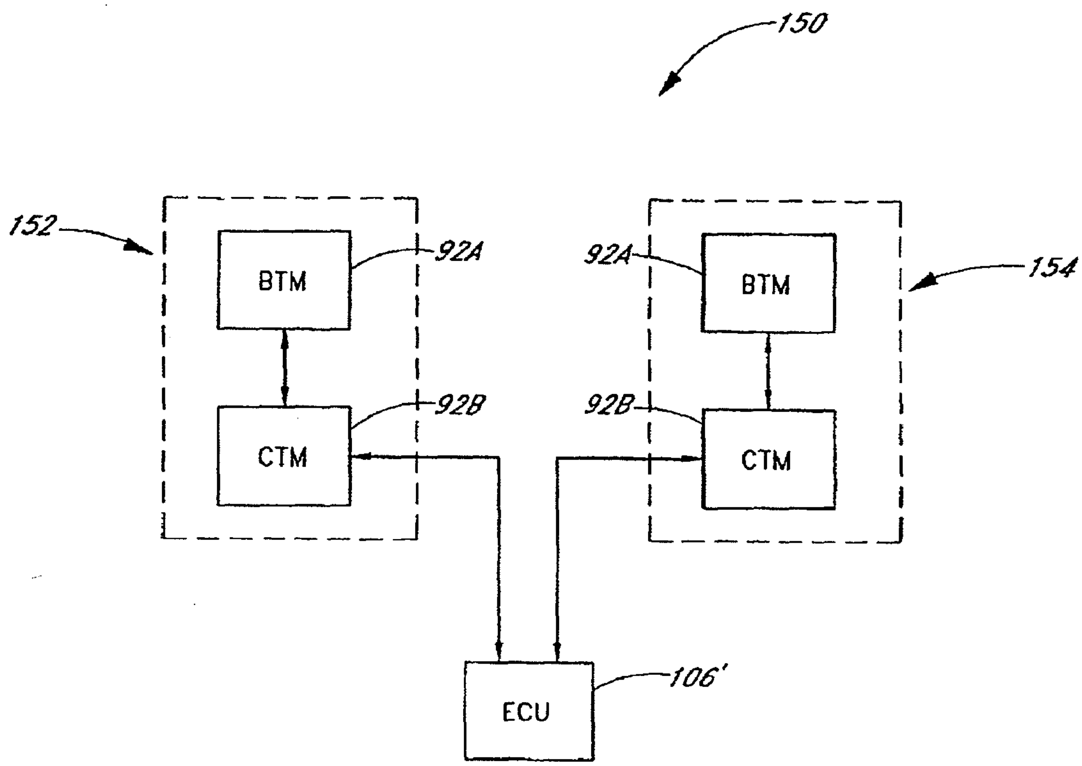

FIG. 6

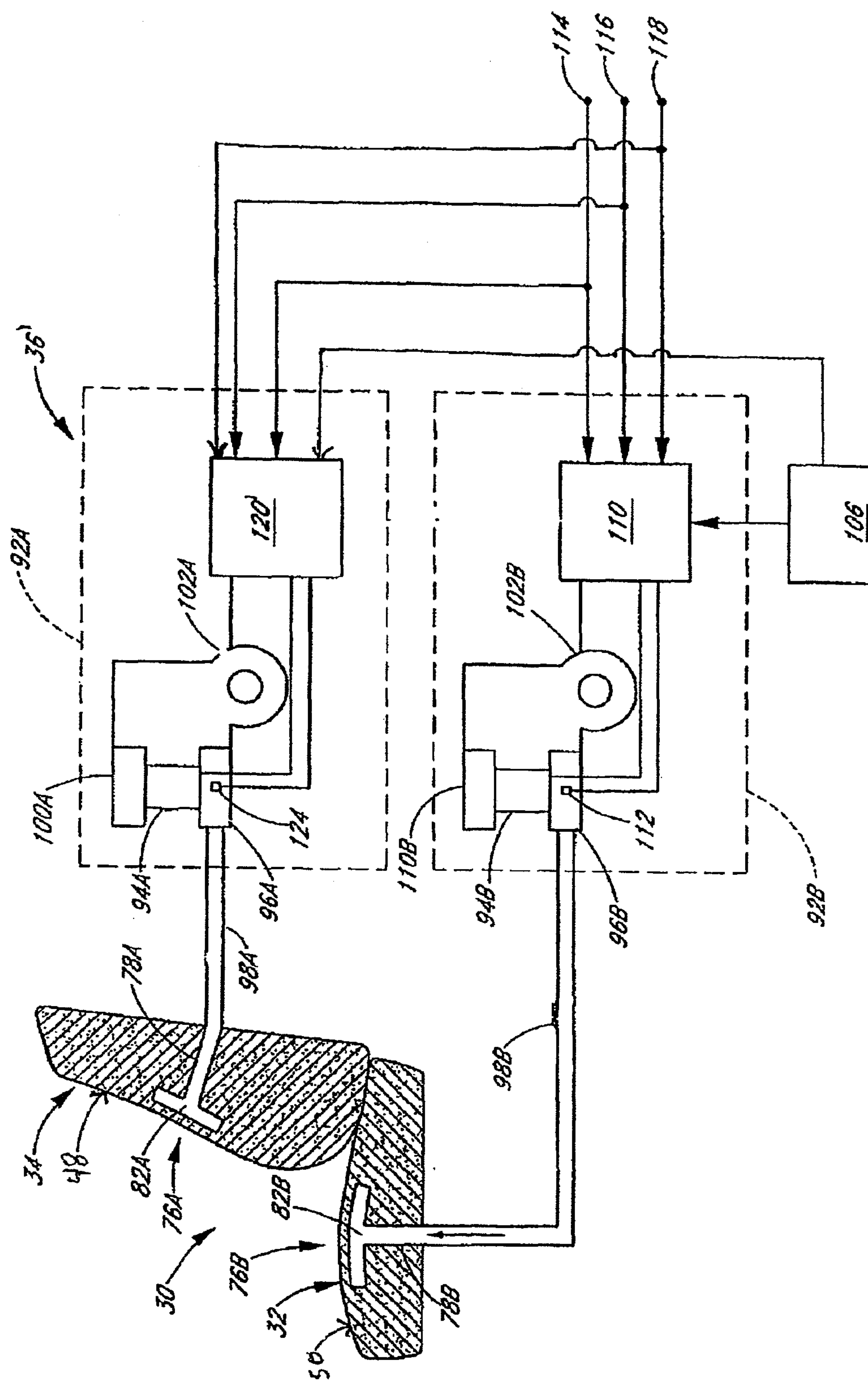
114
116
118
36'
92A
120
110
106
102A
102B
100A
124
94A
96A
110B
94B
112
96B
92B
78A
98A
98B
34
48
82A
76A
82B
30
76B
32
78B
50

FIG. 7

CONTROL SYSTEM FOR THERMAL MODULE IN VEHICLE

PRIORITY INFORMATION

This application claims the priority benefit under 35 U.S.C. § 119(e) of Provisional Application 60/637,725, filed Dec. 20, 2004.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to climate control. More specifically, this invention relates to climate control of a seat.

2. Description of the Related Art

Temperature modified air for environmental control of living or working space is typically provided to relatively extensive areas, such as entire buildings, selected offices, or suites of rooms within a building. In the case of vehicles, such as automobiles, the entire vehicle is typically cooled or heated as a unit. There are many situations, however, in which more selective or restrictive air temperature modification is desirable. For example, it is often desirable to provide an individualized climate control for an occupant seat so that substantially instantaneous heating or cooling can be achieved. For example, an automotive vehicle exposed to the summer weather, where the vehicle has been parked in an unshaded area for a long period, can cause the vehicle seat to be very hot and uncomfortable for the occupant for some time after entering and using the vehicle, even with normal air conditioning. Furthermore, even with normal air-conditioning, on a hot day, the occupant's back and other pressure points may remain sweaty while seated. In the winter, it is highly desirable to have the ability to warm the seat of the occupant quickly to facilitate the occupant's comfort, especially where the normal vehicle heater is unlikely to warm the vehicle's interior as quickly.

For such reasons, there have been various types of individualized climate control systems for vehicle seats. Such climate control systems typically include a distribution system comprising a combination of channels and passages formed in the back and/or seat cushions of the seat. A thermal module conditions the climate of the air and delivers the conditioned air to the channels and passages. The climate conditioned air flows through the channels and passages to cool or heat the space adjacent the surface of the vehicle seat.

There are, however, drawbacks with existing climate control systems for seats. For example, some climate control systems are not easily integrated into existing seat construction methods. Such systems require a significantly greater number of parts as compared to existing automotive seats, and often require complex mechanical parts and/or electrical connections. In the past, this has resulted in increased costs for individualized occupant cooling in automobiles.

In particular, many advanced climate control systems allow the user to control individually the climate for each seat in the vehicle. In some systems, the user may also vary the climate between different portions of the seat. For example, the user may vary the climate settings between the seat cushion and the back cushion. In one arrangement, the user inputs the desired climate setting through an input or control switch. An intermediate control module interprets the signal from the control switch and generates control signals for a pair thermal modules, which are individually associated with the seat and back cushions. A set of power, control and signal wires extend between the thermal modules and the intermediate control module. These wires are used to control and drive the thermal

modules to achieve the desired climate setting. In certain arrangements, seven or more wires may extend between the intermediate control modules and each thermal module. For one seat, therefore, there may be over fourteen wires extending between the intermediate control module and the climate control devices. These wires require a significant amount of space and complicate the design and layout of the climate control system.

Thus, there is a need for an improved climate control apparatus for a climate control system for seats.

SUMMARY OF THE INVENTION

Accordingly, one aspect of the present invention involves a device for thermally conditioning and moving a fluid. The device includes a thermoelectric device to convert electrical energy into thermal energy producing a temperature change in response to an electrical current being applied thereto. A fluid transfer device produces a fluid flow that is in thermal communication with the thermoelectric device so that the thermal energy generated by the thermoelectric device is transferred to the fluid flow. A housing has an outlet and an inlet through which the fluid flow is directed. The thermoelectric device and the fluid transfer device are positioned at least partially within the housing. A sensor is configured to provide a temperature signal that is indicative of the temperature of the fluid flow. A control unit is coupled to the housing and is operatively connected to the sensor. The control unit is configured to receive a set point signal that is indicative of a desired temperature of the fluid flow based and configured to control the thermoelectric device and the fluid transfer device.

Another aspect of the present invention comprises a device for thermally conditioning and moving a fluid. The device includes a thermoelectric device to convert electrical energy into thermal energy producing a temperature change in response to an electrical current being applied thereto. A fluid transfer device produces a fluid flow that is in thermal communication with the thermoelectric device. A sensor is configured to provide a temperature signal that is indicative of the temperature of the fluid flow. A control unit is operatively connected to the sensor. The control unit is configured to receive a set point signal that is indicative of a desired temperature of the fluid flow and, based upon the set point signal and the temperature signal, to control the thermoelectric device and the fluid transfer device. The control unit is also configured to receive a second temperature signal from a second sensor. The second temperature signal is indicative of the temperature of the fluid flow within a second device for thermally conditioning and moving a fluid. The control unit is configured to control the second device based upon the set point signal and the second temperature signal so as to control the temperature and fluid flow within the second device.

Another aspect of the present invention comprises a climate controlled seat assembly that includes a seat cushion having a ventilation system. A main control unit is configured to generate a mode signal for the seat assembly. A first thermal module is configured to thermally condition air at a first portion of the ventilation system. A first sensor is configured to sense a condition of the first thermal module and to provide a condition signal corresponding to the sensed condition. A first control unit is operatively connected to the main control unit, the first sensor and the first thermal module. The first control unit is configured to drive the first thermal unit based upon the mode signal and the condition signal. A second thermal module is configured to thermally condition air at a second portion of the ventilation system. A second control unit is provided for the second thermal module. The first

control unit is configured to control the second control unit based upon the mode signal and the condition signal.

Another aspect of the present invention involves a method for thermally conditioning a space adjacent a seat assembly. In the method, an input signal from an input device is transmitted to a control unit of a first thermal module. The first thermal module is controlled based at least in part upon the input signal to deliver thermally conditioned air to a first portion of a seat assembly. A control signal is transmitted from the control unit of the first thermal module to a control unit of a second thermal module so as to control the second thermal module and deliver thermally conditioned air to a second portion of the seat assembly based at least in part upon the input signal from the input device.

Another aspect of the present invention involves a climate controlled seat assembly that comprises a seat cushion, a main control unit, a first thermal module and a second thermal module. The seat cushion includes a ventilation system having a first portion and a second portion. The main control unit is configured to generate a mode signal for the seat assembly. The first thermal module is configured to thermally condition air that is delivered to the first portion of the ventilation system. The first thermal module comprises a first sensor configured to sense a condition of the first thermal module and to provide a condition signal corresponding to the sensed condition and a first control unit that is operatively connected to the main control unit, the first sensor and the first thermal module. The first control unit is configured to drive the first thermal unit based upon the mode signal and the condition signal of the first thermal module. The second thermal module hat is configured to thermally condition air that is delivered to the second portion of the ventilation system. The second thermal module comprises a second sensor configured to sense a condition of the second thermal module and to provide a condition signal corresponding to the sensed condition and a second control unit that is operatively connected to the main control unit, the second sensor and the second thermal module. The second control unit is configured to drive the second thermal unit based upon the mode signal and the condition signal of the second thermal module.

Further features and advantages of the present invention will become apparent to those of ordinary skill in the art in view of the detailed description of preferred embodiments which follow, when considered together with the attached drawings and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a vehicle seat assembly, which includes a climate control system that is configured in accordance with a preferred embodiment of the present invention;

FIG. **2** is a side view of the vehicle seat assembly of FIG. **1**;

FIG. 2A is a cross-sectional view of the vehicle seat assembly of FIG. **1** taken along line 2A-2A of FIG. **2**.

FIG. 2B is a cross-sectional view of the vehicle seat assembly of FIG. **1** taken along line 2B-2B of FIG. **2**.

FIG. **3** is a front view of the vehicle seat assembly of FIG. **1** with a covering of the seat assembly removed;

FIG. **4** is a schematic illustration of the vehicle seat assembly and climate control system of FIG. **1**;

FIG. **5** is a perspective view of a thermal module of the climate control system of FIG. **1**;

FIG. **6** is a schematic illustration of another embodiment of a climate control system; and

FIG. **7** is a schematic illustration the vehicle seat assembly of FIG. **1** with a modified embodiment of a climate control system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. **1** and **2** illustrate an exemplary embodiment of a seat assembly **30** that comprises a seat **32** and a backrest **34**. The seat assembly **30** includes a climate control system **36**, which will be described in more detail below with reference to FIG. **4**.

When an occupant sits in the seat assembly **30**, the occupant's seat is located generally in a seat area **40** of the seat portion **32** and at least a portion of their legs are supported by a thigh area **42** of the seat portion **32**. In this embodiment, a rear end **44** of the seat portion **32** is coupled to a bottom end **46** of the backrest portion **34**. When the occupant sits in the seat assembly **30**, the occupant's back contacts a front surface **48** of the backrest portion **34** and the occupant's seat and legs contact a top surface **50** of the seat portion **32**. The surfaces **48**, **50** cooperate to support the occupant in a sitting position. The seat assembly **30** can be configured and sized to accommodate occupants of various size and weight.

In the illustrated embodiment, the seat assembly **30** is similar to a standard automotive seat. However, it should be appreciated that certain features and aspects of the seat assembly **30** described herein may also be used in a variety of other applications and environments. For example, certain features and aspects of the seat assembly **30** may be adapted for use in other vehicles, such as, for example, an airplane, a boat, or the like. Further, certain features and aspects of the seat assembly **30** may also be adapted for use in stationary environments, such as, for example, a chair, a sofa, a theater seat, a mattress, and an office seat that is used in a place of business and/or residence.

With continued reference to FIGS. **1** and **2**, the backrest **34** has a front side **54**, a rear side **56**, a top side **58** and a bottom side **60**. The backrest **34** includes a pair of sides **57**, **59** extending between the top side **58** and bottom side **60** for providing lateral support to the occupant of the seat assembly **30**. A lumbar region **62** of the backrest **34** is generally positioned between the sides **57**, **59** of the backrest **34** near the seat portion **32**.

In a similar manner, the seat portion **32** has a front side **64**, a rear side **66**, a top side **68** and a bottom side **70**. The seat portion **32** also includes a pair of sides **69**, **71**, which extending from the rear side **66** and the front side **64** for providing lateral support to the occupant of the seat assembly **30**. In one embodiment, the seat assembly **30** is secured to a vehicle by attaching the bottom side **70** of the seat portion **32** to the floor of a vehicle.

FIG. 2A is a cross-sectional view of a portion of the backrest **34**. As shown, the backrest **34** is generally formed by a cushion **72**, which is covered with an appropriate covering material **74** (e.g., upholstery). The cushion **72** is typically supported on a metallic frame (not shown). In some embodiments, springs may be positioned between the frame and the cushion **72**. The frame provides the seat assembly **30** with structural support while the cushion **72** provides a soft seating surface. The covering material **74** provides an aesthetic appearance and soft feel to the surface of the seat assembly **30**. The seat portion **32** may be constructed in a similar manner as the backrest **34**.

FIG. **3** illustrates the seat assembly with the covering **74** removed thereby exposing the cushion **72**. The cushion **72** can be a typical automotive seat cushion foam or other types

of materials with suitable characteristics for providing support to an occupant. Such materials include, but are not limited to, closed or open-celled foam.

As shown in FIG. 3, the backrest **34** of the seat assembly **30** is provided with a backrest fluid distribution system **76**A. The distribution system **76**A comprises an inlet passage **78**A through from the front side **54** to the rear side **56** of the seat cushion **72**. (See also FIG. 2A). The distribution system **76**A also includes at least one, and often, a plurality of channels **80**A, which extend from the inlet passage **78**A.

As mentioned above, the cushion **72** may be formed from a typical automotive cushion material, such as, for example, an open or closed cell foam. In one embodiment, the cushion **72** is made of foam that is pre-molded to form the passage **78**A and/or the channels **80**A. In another embodiment, the passage **78**A and/or the channels **80**A may be formed by cutting foam out of the seat cushion **72**.

With reference back to FIG. **2**A, the channels **80**A are covered by a scrim **81**A to define distribution passages **82**A for transporting air through the seat assembly **30**. The scrim **81**A includes one or more openings **84**A for delivering air to and/or from the distribution passages **82**A. The scrim **81**A may be formed of a material similar to the cushion **72**. In the illustrated embodiment, the scrim **81**A is attached to the cushion **72** in a manner that limits leakage between the scrim **81**A and cushion **72** thereby directing the flow of air through the openings **84**A. In one embodiment, an adhesive is used to attach the scrim **81**A to the cushion **72**. In other embodiments, a heat stake or fasteners may be used.

With continued reference to FIG. 2A, a distribution layer **86**A is disposed between the scrim **81**A and the seat covering **74**. The distribution layer **86**A spreads the air flowing through the openings **84**A along the lower surface of the covering **74**. To permit airflow between the distribution layer **86**A and the spaces proximal to the front surface **48** of the backrest **34**, the covering **74** may be formed from an air-permeable material. For example, in one embodiment, the covering **74** comprises an air-permeable fabric made of natural and/or synthetic fibers. In another embodiment, the covering is formed from a leather, or leather-like material that is provided with small openings or apertures.

With reference to FIGS. 2B and 3, the seat **32** of the seat assembly **30** is provided with a seat cushion fluid distribution system **76**B. The seat distribution system **76**B also comprises an inlet passage **78**B through from the top side **68** to the bottom side **70** of the seat cushion **72**. As with the backrest distribution system **76**A, the seat distribution system **76**B also includes at least one, and often, a plurality of channels **80**B, which extend from the inlet passage **78**B. These channels **80**B may be configured as described above.

In the seat distribution system **76**B, the channels **80**B are also covered by a scrim **81**B to define distribution passages **82**B for transporting air through the seat assembly **30**. The scrim **81**B includes one or more openings **84**B for delivering air to and/or from the distribution passages **82**B. As described above, the scrim **81**B may be formed of a material similar to the cushion **72** and is preferably attached to the cushion **72** in a manner that limits leakage between the scrim **81**B and cushion **72**. A distribution layer **86**B is disposed between the scrim **81**B and the seat covering **74**.

As will be explained in more detail below, in one embodiment, conditioned air is delivered to the distribution passages **82**A, **82**B through the inlet passages **78**A, **78**B. The air then flows through the openings **84**A, **84**B and into the distribution layer **86**A, **86**B. The air is then directed through the covering **74** to a space adjacent to the front surface **48** of the backrest **34** or the top surface **50** of the seat **32**. In another embodiment, the climate control system **36** is used to remove air, which is adjacent to the front surface **48** of the backrest **34** and/or the top surface **50** of the seat **32**. In such an embodiment, the air is withdrawn through the covering **74** and into the distribution layers **86**A, **84**B. The air is then withdrawn through the openings **84**A, **84**B, into the distribution passages **82**A, **82**B and through the inlet passage **78**A, **78**B.

Given the goal of distributing air through the cushion **72** and along the covering **74**, those of skill in the art will recognize that the distribution systems **76**A, **76**B for the backrest **34** and the seat **32** may be modified in several different manners. For example, the shape and/or number of channels **80**A, **80**B may be modified. In other embodiments, the scrim **81**A, **81**B and/or distribution passages **82**A, **82**B may be combined and/or replaced with other components configured for similar functions. In yet another embodiment, a separate insert may be positioned within the channels **80**A, **80**B for distributing the air. See e.g., co-pending U.S. patent application Ser. No. 10/853,779, filed May 25, 2004, the entire contents of which are hereby incorporated by reference herein. In other embodiments, the distribution systems **76**A, **76**B or portions thereof may be combined with each other.

FIG. **4** is a schematic illustration of the climate control system **36**. In the illustrated embodiment, the climate control system includes a back thermal module **92**A and seat thermal module **92**B. As will be explained below, both thermal modules **92**A, **92**B are configured to provide conditioned air (and/or to remove air in some embodiments) to the distribution systems **76**A, **76**B described above. In this manner, the thermal modules **92**A, **92**B provide a fluid flow to either warm or cool the front surface **48** of the backrest **34** and the top surface **50** of the seat portion **32** respectively. Specifically, the climate control apparatus **36** preferably provides conditioned air that is either heated or cooled relative to the temperature of the front surface **48** of the back rest **32** and the top surface **50** of the seat **32**.

In the illustrated embodiment, the thermal modules **92**A, **92**B preferably each include a thermoelectric device **94**A, **94**B for temperature conditioning (i.e. selectively heating or cooling) the fluid flowing through the device **94**A, **94**B. A preferred thermoelectric device **94**A, **94**B is a Peltier thermoelectric module, which is well known in the art. The illustrated thermal modules **92**A, **92**B preferably also include a main heat exchanger **96**A, **96**B for transferring or removing thermal energy from the fluid flowing through the modules **92**A, **92**B and to the distribution systems **76**A, **76**B. Such fluid is transferred to the distribution systems **76**A, **76**B through conduits **98**A, **98**B (see e.g., U.S. application Ser. No. 10/973,947, filed Oct. 25, 2004, which is hereby incorporated by reference herein). The modules **92**A, **92**B also preferably include a waste heat exchanger **100**A, **100**B that extends from the thermoelectric device **94**A, **94**B generally opposite the main heat exchanger **96**A, **96**B. A pumping device **102**A, **102**B is preferably associated with each thermal module **92**A, **92**B for directing fluid over the main and/or waste heat exchangers **96**A, **96**B, **100**A, **100**B. The pumping devices **102**A, **102**B may comprise an electrical fan or blower, such as, for example, an axial blower and/or radial fan. In the illustrated embodiment, a single pumping device **102**A, **102**B may be used for both the main and waste heat exchangers **96**A, **96**B, **100**A, **100**B. However, it is anticipated that separate pumping devices may be associated with the waste and heat exchanges **96**A, **96**B, **100**A, **100**B.

It should be appreciated that the thermal modules **92**A, **92**B described above represents only one exemplary embodiment of a device that may be used to condition the air supplied to the distribution systems **76**A, **76**B. Any of a variety of differ-

ently configured thermal modules may be used to provide conditioned air. Other examples of thermal modules that may be used are described in U.S. Pat. Nos. 6,223,539, 6,119,463, 5,524,439 or 5,626,021, which are hereby incorporated by reference in their entirety. Another example of such a thermal module is currently sold under the trademark Micro-Thermal Module™ by Amerigon, Inc. In another example, the thermal module may comprise a pump device without a thermoelectric device for thermally conditioning the air. In such an embodiment, the pumping device may be used to remove or supply air to the distribution system **76**A, **76**B. In yet another embodiment, the thermal modules **92**A, **92**B, may share one or more components (e.g., pumping devices, thermoelectric devices, etc.) with the vehicles general climate control system.

In operation, fluid in the form of air can be delivered from the thermal modules **92**A, **92**B, through the conduits **98**A, **98**B to the distribution systems **76**A, **76**B. As described above, the air flows through the passages **82**A, **82**B, into the openings **84**A, **84**B and then along the distribution layer **86**A, **86**B and through the covering **74**. In this manner, conditioned air can be provided to the front surface **48** of the backrest **34** and the top surface **50** of the seat **32**.

In a modified embodiment, air from within the passenger compartment of the automobile can be drawn through the covering **74**, into the distribution layer **86**A, **86**B and through the openings **84**A, **84**B. The air then can flow through the distribution passages **82**A, **82**B, into the inlet passage **78**A, **78**B and then into the conduit **98**A, **98**B. In this manner, the climate control system **36** can provide suction so that air near the surface of the seat assembly **30** is removed.

A control system **104** for the climate control system **36** will now be described with continued reference to FIG. **4**. As shown, the control system **104** includes a user input device **106** through which the user of the climate control system **36** can provide a control setting or set mode for the climate control system **36**. The control setting can comprise a specific temperature setting (e.g., 65 degrees), a more general temperature setting (e.g., "hot" or "cold"), and/or a setting for the pumping device (e.g., "high," "medium," or "low"). Depending upon the desired configuration, the input device **106** may include any of a variety of input devices, such as, for example, dials, buttons, levers, switches, etc. The user input device **106** may also include a user output that provides visual or audio indicia of the control setting (e.g., an LED display).

With continued reference to FIG. **4**, the input device **106** is operatively connected to a seat control module **110**, which in the illustrated embodiment is associated with the seat thermal module **92**B. The seat control module **110** is, in turn, operatively connected to the pumping device **102**B and the thermoelectric device **94**B. In addition, a temperature sensor **112** is provided to measure the temperature of the fluid conditioned by the thermoelectric device **94**B. The temperature sensor **112** is operatively connected to the seat control module **110**. The seat control module **110** is preferably also operatively connected to a power source **114** and a ground source **116** and includes an appropriate power control unit to provide sufficient electrical capacity to operate all of the aforementioned devices (**92**B, **94**B, **112**) of the seat thermal module **92**B. The seat control module **110** preferably also has a controller that is configured to receive the occupant inputs from the input device **106** and the temperature information from the temperature sensor **112**. From this information, the seat control module **110** is configured to make adjustments to the operation of the thermoelectric device **94**B and the fluid pump **102**B according to a predetermined logic designed to ensure occupant comfort and to protect against system damage.

Those of skill in the art will appreciate that the seat control module can comprise a hard-wired feed back control circuit, a dedicated processor or any other control device that can be constructed for performing the steps and functions described herein. In additions, the controller within the seat control module **110** may be combined or divided as deemed appropriate.

Various components are described as being "operatively connected" to the control unit. It should be appreciated that this is a broad term that includes physical connections (e.g., electrical wires) and non-physical connections (e.g., radio or infrared signals). It should also be appreciated that "operatively connected" includes direct connections and indirect connections (e.g., through an additional intermediate device).

The seat control module **110** optionally may also be configured to receive a signal from a vehicle control device **118** that indicates whether the vehicle's ignition has been turned on. In this manner, the seat control module **110** may be configured to allow operation of the thermal module **92**B only if the vehicle's engine is running.

With continued reference to FIG. **4**, the backrest thermal module **92**A includes a backrest control module **120**. As shown, the backrest control module **120** is operatively connected to the thermoelectric device **94**A and the fluid pump **102**A for the backrest **34**. The backrest control module **120** is connected to the power source **114** and the ground source **116** and includes a controller configured to provide sufficient electrical capacity to operate the thermoelectric device **94**A and the fluid pump **102**A. As will be explained below, the backrest control module **120** is configured to receive a control signal from the seat control module **110**. From this information, the backrest control module **120** operates the thermoelectric device **94**B and the fluid pump **102**B to ensure occupant comfort and safety, and protect against system damage. Those of skill in the art will appreciate that the backrest control module **120** can comprise a hard wired feed back control circuit, a dedicated processor or any other control device that can be constructed for performing the steps and functions described herein.

In the illustrated embodiment, a communication line **122** operatively connects the backrest control module **120** to the seat control module **110**. In one embodiment, the seat control module **110** is configured to receive the inputs from the input device **106** to make adjustments to the operation of the thermoelectric device **94**A and the fluid pump **96**A in the backrest thermal module **92**A according to a predetermined logic designed to ensure occupant comfort and safety, and protect against system damage. The control signals generated by the seat control module **110** are transmitted to the backrest control module **120** through the communication line **122**.

The illustrated embodiment optionally includes a backrest temperature sensor **124** for measuring the temperature of the fluid that has been thermally conditioned by the backrest thermal module **92**A. The information from this temperature sensor **124** may optionally be transmitted through the communication line **122** to the seat control unit **110**. In such a configuration, the seat control unit **110** may be configured to use this temperature signal to generate the control signals transmitted to the backrest control unit **120**. In yet another modified embodiment, the control unit **120** for the backrest **34** may be operatively connected directly to the input device **106** in a manner similar to that described above for the control unit **110** for the seat **32**. An example of such an embodiment will be described in more detail below with reference to FIG. **7**. It should also be appreciated that the control unit **120** for the

backrest **34** may be operatively connected to the power source **114** and the ground source **116** through the communication line **122**.

In the above description, the control units **110**, **120** are described as being associated with the "back" or "seat" cushion. In modified embodiments, it should be appreciated that the features of the back and seat controllers may be reversed. That is, the backrest control module **120** may be configured to interpret the signals from the user input device **106** and to control the seat control module. However, the above-described arrangement is generally preferred because in most applications there is generally more room in the seat cushion **32** for various electrical connections that are described above. In still other embodiments, the features of the back and seat controllers may be applied to different zones of a seat, such as, for example, a top and bottom portion of a backrest. In other embodiments, the features of the back and seat controllers may be applied to different zones of an occupant area that are to be thermally conditioned, such as, for example, back and rear seat assemblies or left and right seat assemblies.

In a preferred embodiment, the backrest control unit **120** and/or the seat control unit **110** are generally coupled to the other components of their respective thermal modules **92A**, **92B** and, more preferably, disposed substantially within the same housing or protective casing **130** which contains the thermoelectric device **94A**, **94B** and fluid pumps **102A**, **102B**. FIG. **5** is an illustration of an exemplary cushion thermal unit **92B**, which includes a casing **130** that generally surrounds the thermoelectric device **94B** and fluid pump **102B**. The casing **130** preferably also surrounds the seat control module **110**. Electrical wires **132** are operatively connected to the seat control module **110** and extend through an opening **134** in the casing **130**. In the illustrated embodiment, the electrical wires **132** provide the operational connection to the input device **106**, power source **114**, ground source **116** and/or engine control unit **118**. An electrical connector (not shown) may be provided at one end of the electrical wires **132** for providing a convenient connection point. The electrical wires may be positioned within a protective tube **138** to form what is often referred to in the art as a "pig tail."

With continued reference to FIG. **5**, another set of electrical wires **140** may be used to form the communication line **122** between the seat control unit **110** and the backrest control unit **120**. These electrical wires **140** preferably also extend from an opening in the casing **130**. These wires **140** may be positioned within a protective tube **141** to form a "pig tail." The electrical wires **140** may also provide the connection between the backrest control module **120** and the power source **114** and ground source **116**.

The above described embodiments have several advantages. For example, there are no physically separate independent controllers for controlling the back and seat thermal modules **92A**, **92B** as is typically found in the prior art. This reduces the amount of space required by the climate control system **36** and reduces the complexity of the overall system design. Advantageously, the system **36** also requires fewer connections between various components. As described above, the prior art often required seven or more electrical connections that extend between the intermediate controller and the thermal modules **92A**, **92B**. The illustrated embodiment significantly reduces the number of these connections, thereby decreasing the complexity of the system, which reduces installation time and saves space.

FIG. **6** illustrates a climate control system **150** which is configured to control the climates of two seat assemblies **152**, **154**. As shown, the system **150** includes a back and seat thermal modules **92A**, **92B** as described below for each seat.

The seat thermal modules **92B** of each seat are operatively connected to an input device **106'**, which may include appropriate user interface such that the user may select the desired climate control for each seat. Those of skill in the art will recognize that the above-described system may be expanded to three, four or more seats and/or seats of different configurations and/or having more than two thermal units associated with each seat.

FIG. **7** illustrates a modified embodiment of a climate control system **36'**. In FIG. **7**, like elements to those shown in FIG. **4** are designated with the same reference numbers used in FIG. **4**. In addition, only certain elements of the climate control system **36'** will be described in detail below. For those elements not described in detail, reference may be made to the previous detailed description of those elements.

As with the embodiment shown in FIG. **4**, the climate control system **36'** includes a user input device **106** through which the user of the climate control system **36'** can provide a control setting or set mode for the climate control system **36'**. As will be explained below, in this embodiment, the user input device **106** is operatively connected to both the seat control module **110** and the back control module **120'**.

The seat control module **110** is operatively connected to the pumping device **102B** and the thermoelectric device **94B**. In addition, a temperature sensor **112** is provided to measure the temperature of the fluid conditioned by the thermoelectric device **94B**. The temperature sensor **112** is operatively connected to the seat control module **110**. The seat control module **110** is preferably also operatively connected to a power source **114** and a ground source **116** and includes an appropriate power control unit to provide sufficient electrical capacity to operate all of the aforementioned devices (**92B**, **94B**, **112**) of the seat thermal module **92B**. The seat control module **110** may also be operatively connected to a vehicle control device **118** that indicates whether the vehicle's ignition has been turned on. As described above with reference to FIG. **4**, the seat control module **110** preferably also has a controller that is configured to receive the occupant inputs from the input device **106** and the temperature information from the temperature sensor **112**. From this information, the seat control module **110** can make adjustments to the operation of the thermoelectric device **94B** and the fluid pump **102B** according to a predetermined logic designed to ensure occupant comfort and to protect against system damage.

As mentioned above, in this embodiment, the back control unit **120'** is also operatively connected to the user input device **106**. The back control module **120'**, in turn, is operatively connected to a pumping device **102A** and a thermoelectric device **94A**. In addition, a temperature sensor **124** may be provided to measure the temperature of the fluid conditioned by the thermoelectric device **94A**. The temperature sensor **124** is operatively connected to the back control module **120'**. The back control module **120'** is preferably also operatively connected to the power source **114** and the ground source **116** and includes an appropriate power control unit to provide sufficient electrical capacity to operate all of the aforementioned devices (**92A**, **94A**, **124**) of the back thermal module **92A**. As with the seat control module **110**, the back control module **120'** preferably has a controller that is configured to receive the occupant inputs from the input device **106** and the temperature information from the temperature sensor **124**. From this information, the back control module **120'** makes adjustments to the operation of the thermoelectric device **94A** and the fluid pump **102A** according to a predetermined logic designed to ensure occupant comfort and to protect against system damage.

In a preferred embodiment, the backrest control unit **120** and/or the seat control unit **110** are generally coupled to the other components of their respective thermal modules **92**A, **92**B and, more preferably, disposed substantially within the same housing or protective casing which contains the respective thermoelectric device **94**A, **94**B and fluid pumps **102**A, **102**B.

In one embodiment, the back control module **120'** and the seat control module **110** are substantially similar such that the thermal modules **92**A, **92**B are also substantially similar. Such an arrangement allows for the same type of thermal module to be used for both the seat and back cushions **32**, **34**, while consequentially reducing costs associated with inventory and production as compared to a system that utilizes two different types of thermal modules. In addition, as with the embodiment of FIG. **3**, there are no physically separate independent controllers for controlling the back and seat thermal modules **92**A, **92**B as is typically found in the prior art. This reduces the amount of space required by the climate control system **36'** and reduces the complexity of the overall system design. Advantageously, the system **36'** also requires fewer connections between various components. As described above, the prior art often required seven or more electrical connections that extend between the intermediate controller and the thermal modules **92**A, **92**B. The illustrated embodiment significantly reduces the number of these connections, thereby decreasing the complexity of the system, which reduces installation time and saves space.

To assist in the description of the disclosed embodiments, words such as upward, upper, downward, lower, vertical, horizontal, upstream, and downstream have and used above to describe the accompanying figures. It will be appreciated, however, that the illustrated embodiments can be located and oriented in a variety of desired positions.

Although the foregoing description of the preferred embodiments has shown, described, and pointed out certain novel features, it will be understood that various omissions, substitutions, and changes in the form of the detail of the apparatus as illustrated, as well as the uses thereof, may be made by those skilled in the art without departing from the spirit of this disclosure. Consequently, the scope of the present invention should not be limited by the foregoing discussion, which is intended to illustrate rather than limit the scope of the invention.

What is claimed is:

1. A device for thermally conditioning and moving a fluid to a climate controlled seat assembly, comprising:

a thermoelectric device to convert electrical energy into thermal energy producing a temperature change in response to an electrical current being applied thereto;

a fluid transfer device to produce a fluid flow that is in thermal communication with the thermoelectric device so that the thermal energy generated by the thermoelectric device is transferred to or from the fluid flow;

a protective casing configured to be positioned within or adjacent the climate controlled seat assembly, the protective casing defining an interior space and having an outlet and an inlet through which the fluid flow is directed, the thermoelectric device and the fluid transfer device being positioned within the interior space of the protective casing;

a sensor configured to provide a temperature signal that is indicative of a temperature of the fluid flow;

a control unit positioned within the protective casing and operatively connected to the sensor, the control unit configured to receive a set point signal that is indicative of a desired temperature of the fluid flow, and based upon the set point signal and the temperature signal, to control the thermoelectric device and the fluid transfer device; and

electrical wires connected to the control unit and extending through an opening in the protective casing.

2. The device as in claim **1**, additionally comprising a second thermoelectric device to convert electrical energy into thermal energy producing a temperature change in response to an electrical current being applied thereto, a second fluid transfer device to produce a fluid flow that is in thermal communication with the thermoelectric device so that the thermal energy generated by the thermoelectric device is transferred to the fluid flow, and a second control unit for operating the second thermoelectric device and the second fluid transfer device, wherein the second thermoelectric device, the second fluid transfer device and the second control unit are situated within a second protective casing.

3. The device as in claim **2**, wherein the control unit is operatively connected to the second control unit and the control unit is configured to at least partially control the second thermoelectric device and the second fluid transfer device based upon the set point signal and the temperature signal.

4. The device as in claim **2**, in combination with a seat assembly, the seat assembly comprising a backrest portion and a seat portion.

5. The device as in claim **4**, wherein the backrest portion includes a first distribution system in fluid communication with the first fluid transfer device and the seat portion includes a second distribution system in fluid communication with the second fluid transfer device.

6. A method for thermally conditioning an area adjacent to a seat assembly, comprising:

transmitting an input signal from an input device to a first control unit of a first thermal module, the first thermal module comprising an outer housing enclosing an interior space, the first control unit being positioned within the interior space;

controlling the first thermal module based at least in part upon the input signal to deliver thermally conditioned air to a first portion of a seat assembly; and

transmitting a control signal from the first control unit of the first thermal module to a second control unit of a second thermal module so as to control the second thermal module and deliver thermally conditioned air to a second portion of the seat assembly based at least in part upon the input signal from the input device;

wherein the first thermal module comprises a thermoelectric device and a fluid transfer device, the thermoelectric device and the fluid transfer device being positioned within the interior space of the housing; and

further comprising coupling the housing to the seat assembly;

wherein the first control unit is configured to control at least one of the thermoelectric device and the fluid transfer device based in part on the input signal from the input device.

7. The method as in claim **6**, additionally comprising sensing a temperature of thermally conditioned air that is delivered to the first portion of the seat assembly.

8. The method as in claim **7**, additionally comprising controlling the first thermal module based at least in part upon the sensed temperature of thermally conditioned air that is delivered to the first portion of the seat assembly.

9. The method as in claim **6**, additionally comprising sensing a temperature of thermally conditioned air that is delivered to the second portion of the seat assembly.

10. The method as in claim 9, additionally comprising transmitting the sensed temperature of thermally conditioned air that is delivered to the second portion of the seat assembly to the second control unit.

11. The method as in claim 10, additionally comprising transmitting a signal regarding the sensed temperature of thermally conditioned air that is delivered to the second portion of the seat assembly to the first control unit, the transmission of such signal being configured to occur through at least one electrical wire, the electrical wire electrically connecting the first control unit to the second control unit.

12. A self-contained thermal module configured for use with a climate controlled seat assembly, comprising:

a housing having an enclosed interior space, the housing comprising a fluid inlet and a fluid outlet;

a thermoelectric device;

a plurality of heat exchange members in thermal communication with the thermoelectric device;

a fluid transfer device configured to transfer a fluid from the fluid inlet to the fluid outlet at least partially through the heat exchange members in order to selectively heat or cool the fluid;

a sensor adapted to provide a temperature signal indicative of a temperature of the fluid that has been transferred through the heat exchange members; and

a controller operatively connected to the sensor, the controller configured to control at least one of the thermoelectric device and the fluid transfer device control based at least in part on the temperature signal;

wherein the thermoelectric device, the heat exchange members, the fluid transfer device and the controller are situated within the enclosed interior space of the housing;

wherein the self-contained thermal module can be installed in a climate controlled seat assembly without the need for an independent control unit that is physically separated from the housing.

13. The thermal module of claim 12, wherein the housing further comprises an opening, the opening being configured to connect at least one wire from outside the housing to the controller.

14. The thermal module of claim 13, wherein the wire is electrically connected to a power source, the sensor or a user input device.

15. The thermal module of claim 12, wherein the fluid outlet is configured to be placed in fluid communication with at least one fluid distribution member of a climate controlled seat assembly.

16. A method of adapting a seat assembly with a temperature control device, the method comprising:

providing a seat assembly having a seat back portion and a seat bottom portion, at least one of the seat back portion and the seat bottom portion comprising a fluid distribution member configured to receive fluid and generally distribute it toward a seated occupant;

securing a first self-contained thermal module to the seat back portion or the seat bottom portion, said first thermal module comprising:

a housing having a fluid inlet and a fluid outlet;

a thermoelectric device;

a fluid transfer device configured to transfer a fluid from the fluid inlet to the fluid outlet past the thermoelectric device to selectively heat or cool the fluid;

a controller configured to control at least one of the thermoelectric device and the fluid transfer device control;

wherein the thermoelectric device, the fluid transfer device and the controller are positioned within an interior space of the housing; and

wherein the housing comprises an opening for routing at least one electrical connection therethrough;

providing a user input device configured to permit a user to select a desired temperature setting;

coupling the first thermal module to the seat assembly; and

electrically connecting the controller of the first thermal module to the user input device and a power supply using wire connections routed through the opening of the housing;

wherein the first thermal module can operate without the need of an independent control unit that is physically separated from the housing.

17. The method of claim 16, further comprising providing a sensor in data communication with the controller of the thermal module, the sensor being adapted to provide a temperature signal indicative of a temperature of the fluid that has been transferred past the thermoelectric device.

18. The method of claim 16, further comprising securing a second self-contained thermal module to one of the seat back portion and the seat bottom portion, the second thermal module being configured to operate without the need of an independent control unit.

19. The method of claim 18, wherein the second thermal module comprises a second controller that is in data communication with the controller of the first thermal module.

20. A climate controlled seat assembly comprising:

a seat back portion and a seat bottom portion;

a first thermal module comprising:

a protective housing separate and independent from the seat back portion and the seat bottom portion, the protective housing having a fluid inlet and a fluid outlet, the protective housing defining an interior space;

a thermoelectric device;

a fluid transfer device configured to transfer a fluid from the fluid inlet to the fluid outlet through or near the thermoelectric device to selectively heat or cool the fluid; and

a control module configured to control the thermoelectric device and the fluid transfer device depending at least partially on a temperature signal, the temperature signal being based on the a temperature of thermally conditioned fluid that has been transferred through or near the thermoelectric device;

wherein the thermoelectric device, the fluid transfer device and the control module are at least partially situated within the interior space of the protective housing; and

a fluid distribution member having an entry passage, the entry passage being in fluid communication with the fluid outlet of the first thermal module;

wherein the fluid distribution member is positioned within at least one of the seat back portion and the seat bottom portion of the seat assembly, and wherein thermally conditioned fluid entering the entry passage of the fluid distribution member is configured to be distributed toward a seated occupant of the seat assembly;

wherein the first thermal module can be installed in the seat assembly and can be properly operated without the need for an independent control unit that is physically separated from the protective housing.

21. The seat assembly of claim 20, further comprising a user input device, the user input device being operatively connected to the control module of the first thermal module.

22. The seat assembly of claim 20, further comprising a second thermal module, the second thermal module configured to provide thermally conditioned fluid to a different part of the seat assembly.

23. The seat assembly of claim 20, wherein the thermoelectric device comprises a Peltier circuit and the fluid transfer device comprises a radial fan.

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